ECG

A to Z

drsherwanshal@gmail.com

What is an ECG?

The electrocardiogram (ECG) is a representation of the electrical events of the cardiac cycle.

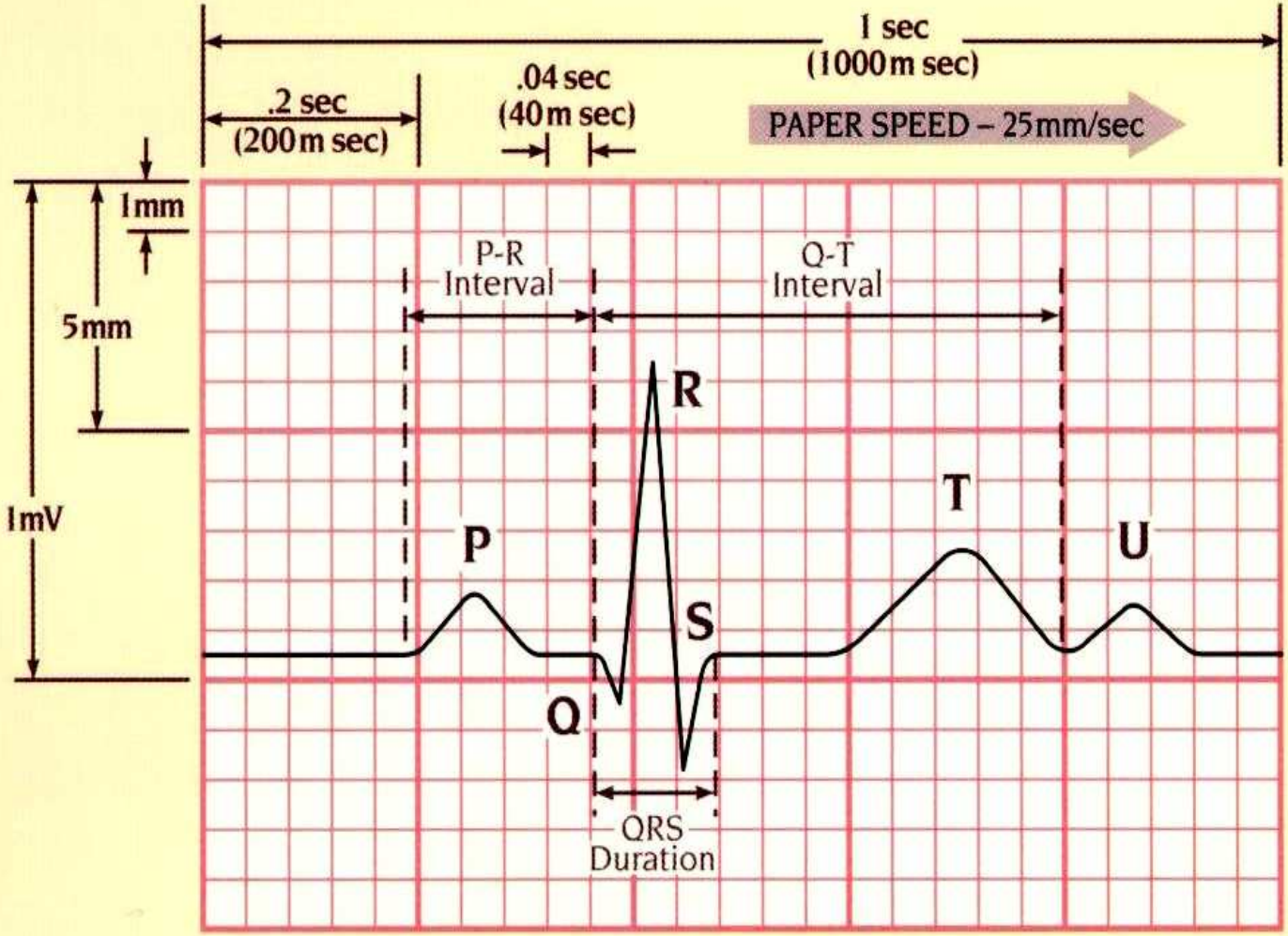
Each event has a distinctive waveform, the study of which can lead to greater insight into a patient's cardiac pathophysiology.

What types of pathology can we identify and study from ECGs?

- Arrhythmias
- Myocardial ischemia and infarction
- Pericarditis
- Chamber hypertrophy
- Electrolyte disturbances (i.e. hyperkalemia, hypokalemia)
- Drug toxicity (i.e. digoxin and drugs which prolong the QT interval)

ECG PAPER

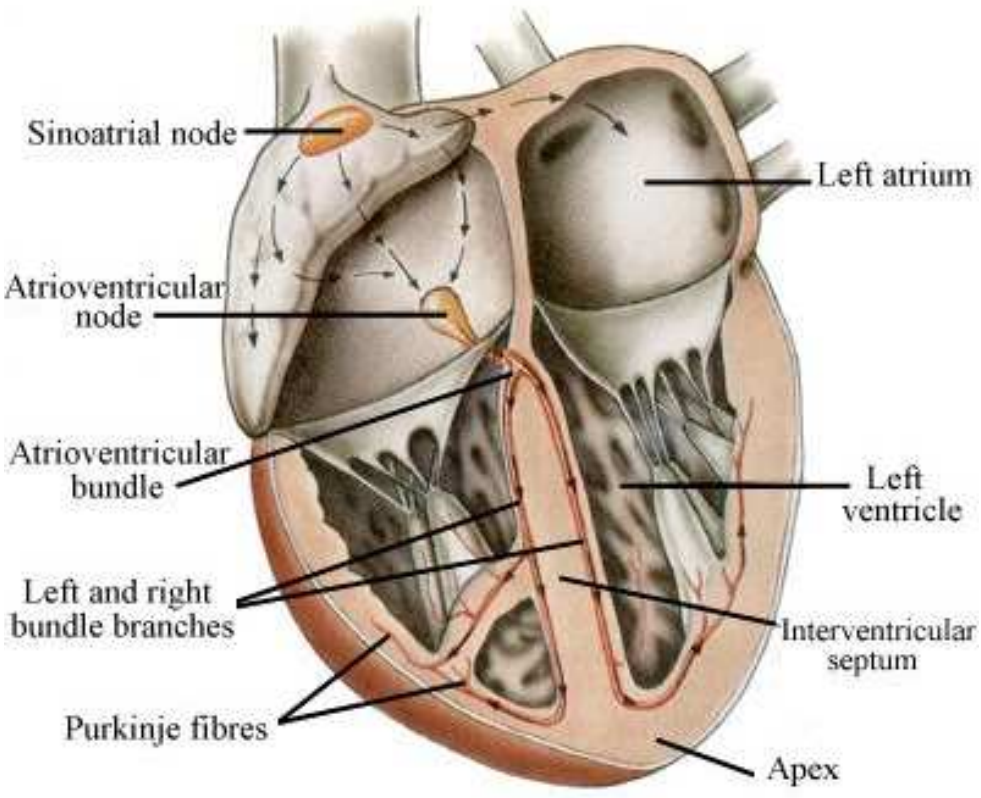
- Light lines small squares- 1 X 1 mm
- Bold lines large squares 5 X 5 mm
- Horizontal axis=time
  1. Distance across small square=0.04 sec.
  2. Distance across large square=0.2 sec.
- Vertical axis=voltage
  1. Distance across small square=0.1 mV
  2. Distance across large square=0.5 mV

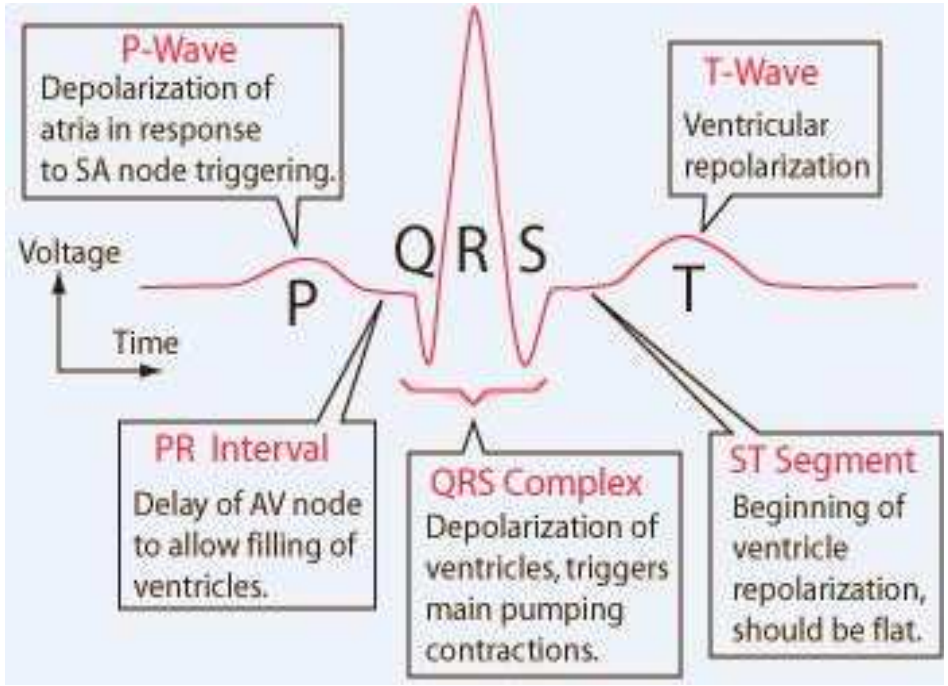


VERTICAL AXIS	1 Small Square = 1mm (0.1mV)
	1 Large Square = 5mm (0.5mV)
	2 Large Squares = 1mV

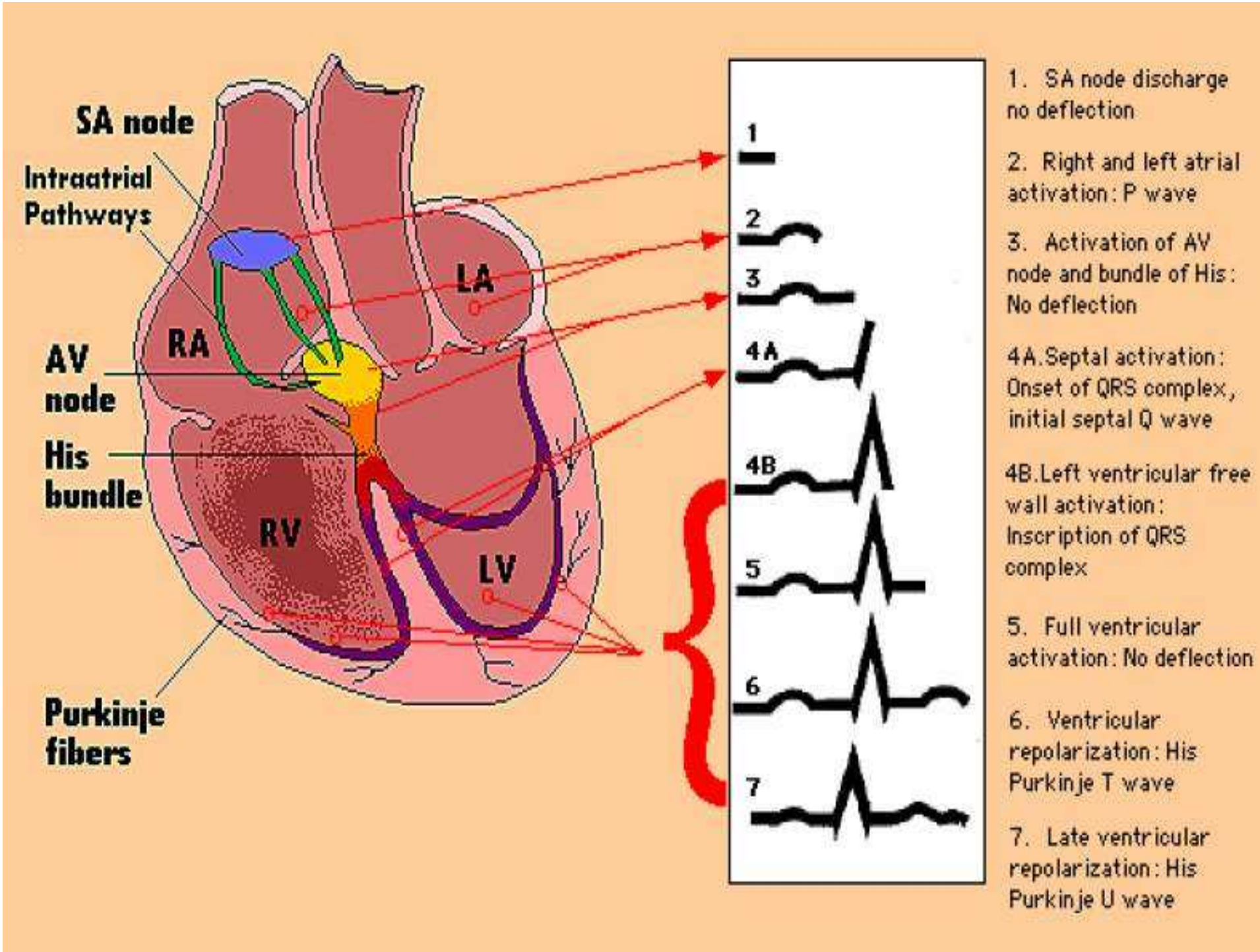
HORIZONTAL AXIS	1 Small Square = .04 sec (40 m sec)
	1 Large Square = .2 sec (200 m sec)
	5 Large Squares = 1 sec (1000 m sec)

Anatomy of Heart and ECG signal





Normal ECG signal


SA node
Intraatrial Pathways
AV node
His bundle
Purkinje fibers
RA
LA
RV
LV
1
2
3
4A
4B
5
6
7
1. SA node discharge no deflection
2. Right and left atrial activation: P wave
3. Activation of AV node and bundle of His: No deflection
4A. Septal activation: Onset of QRS complex, initial septal Q wave
4B. Left ventricular free wall activation: Inscription of QRS complex
5. Full ventricular activation: No deflection
6. Ventricular repolarization: His Purkinje T wave
7. Late ventricular repolarization: His Purkinje U wave

ECG Leads

Leads are electrodes which measure the difference in electrical potential between either:

1. Two different points on the body (bipolar leads)

2. One point on the body and a virtual reference point with zero electrical potential, located in the center of the heart (unipolar leads)

ECG Leads

The standard ECG has 12 leads:

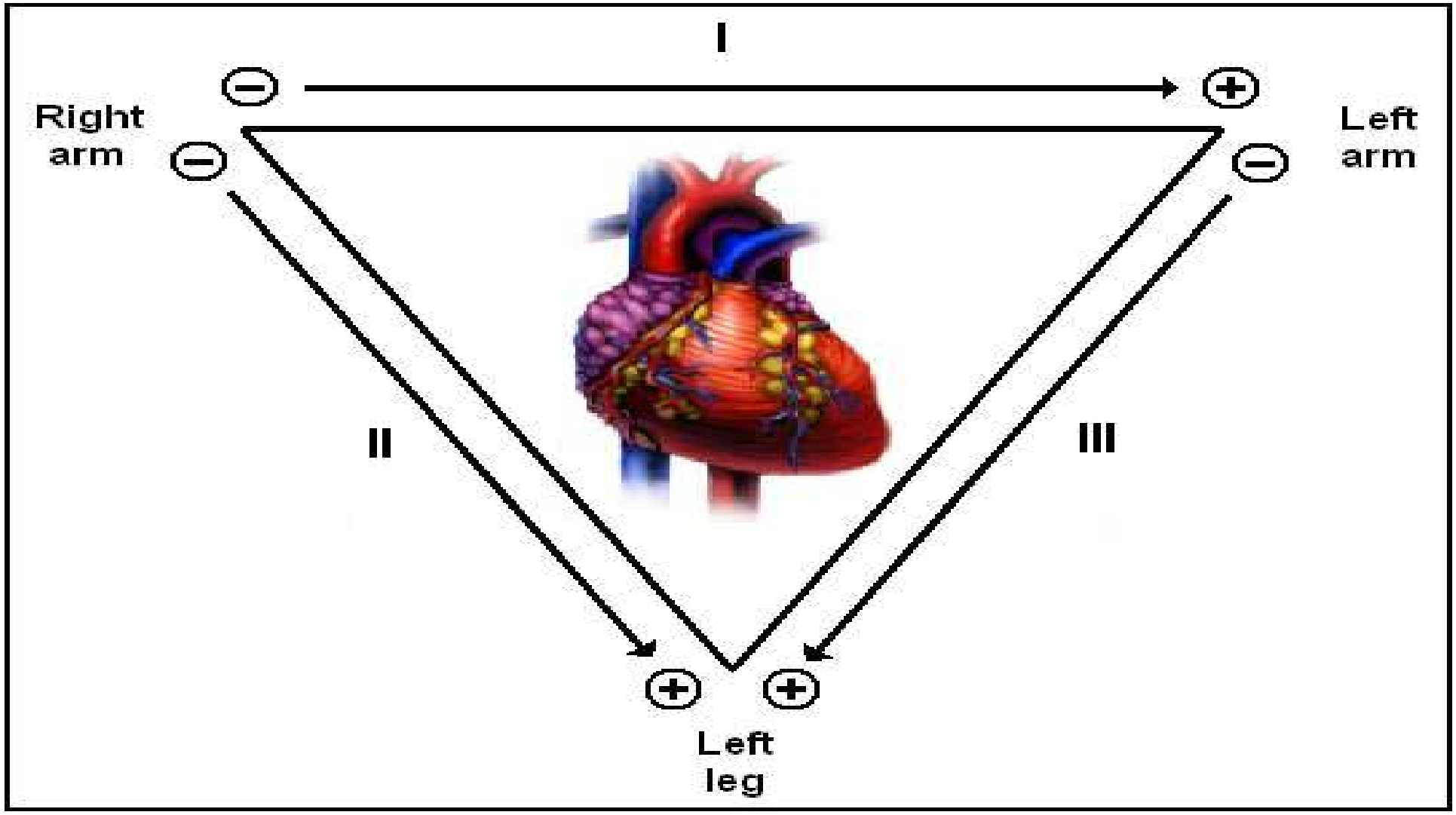
3 Standard Limb Leads

3 Augmented Limb Leads

6 Precordial Leads

The axis of a particular lead represents the viewpoint from which it looks at the heart.

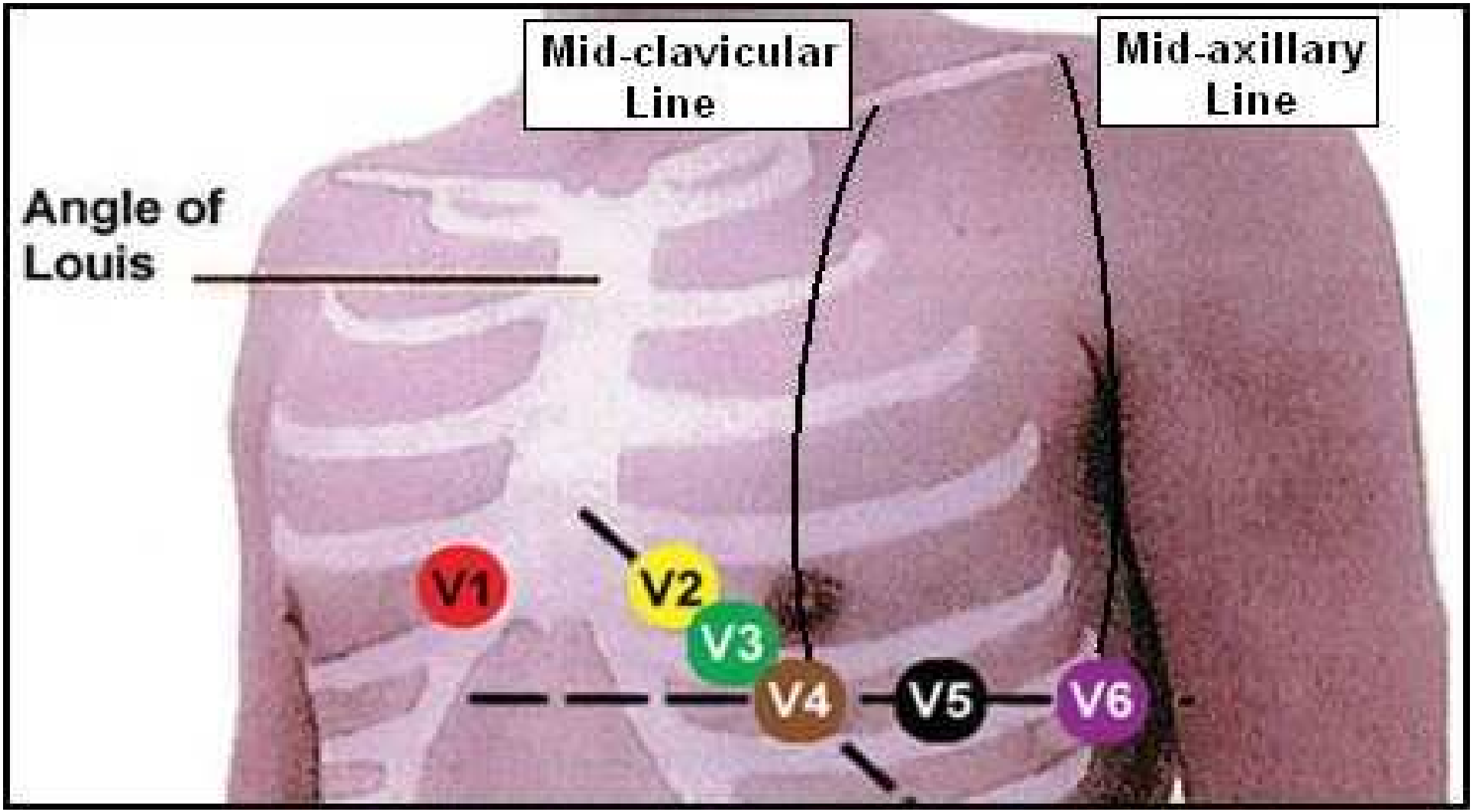
Standard Limb Leads



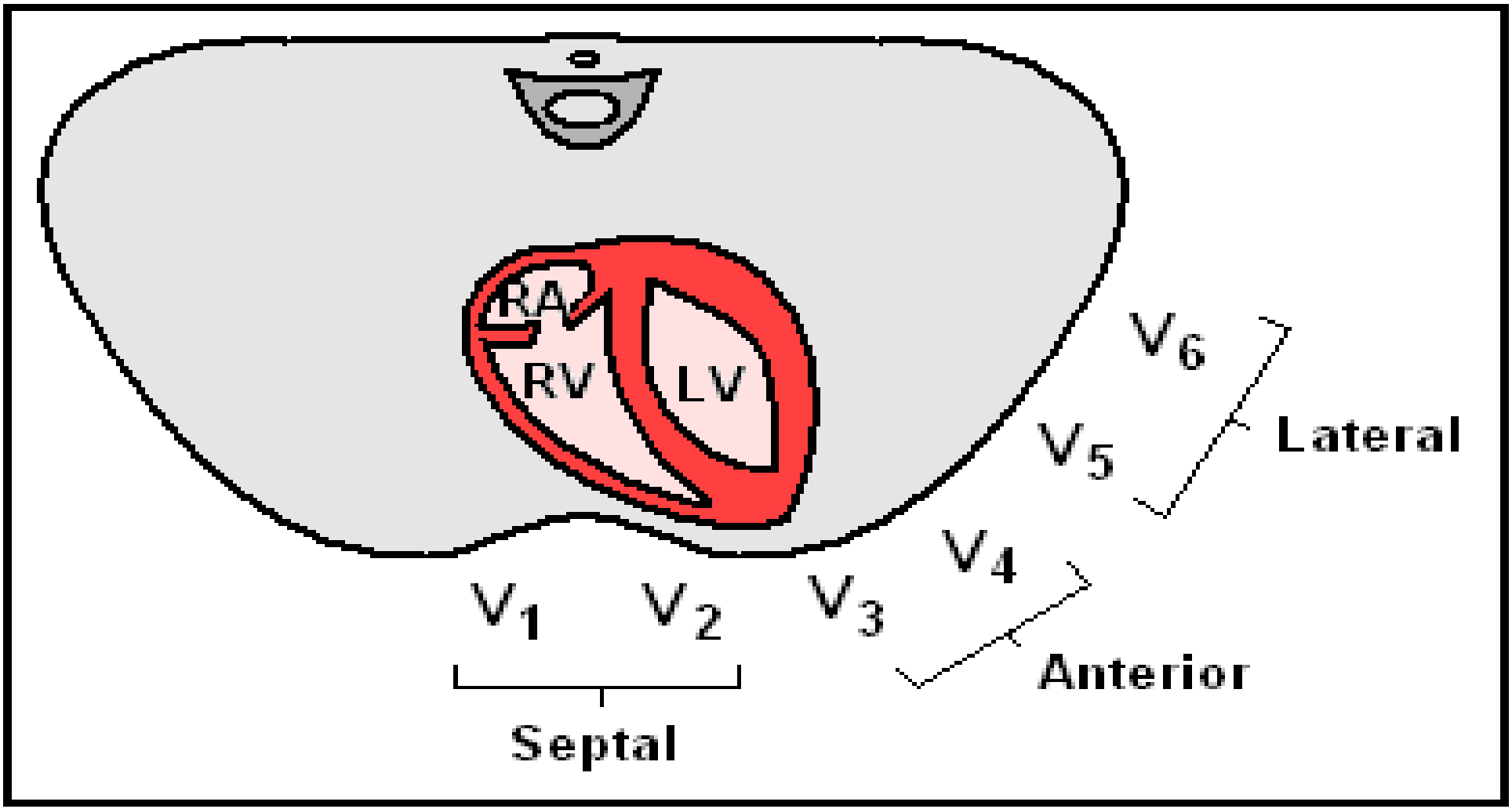
Precordial Lead Placement

- V_1: 4th intercostal space, right sternal border
- V_2: 4th intercostal space, left sternal border
- V_3: midway between V_2 and V_4
- V_4: 5th intercostal space, left midclavicular line
- V_5: level with V_4, anterior axillary line
- V_6: level with V_4, mid axillary line

Precordial Leads



Precordial Leads



Summary of Leads

	Limb Leads	Precordial Leads
Bipolar	I, II, III (standard limb leads)	-
Unipolar	aVR, aVL, aVF (augmented limb leads)	V_1-V_6

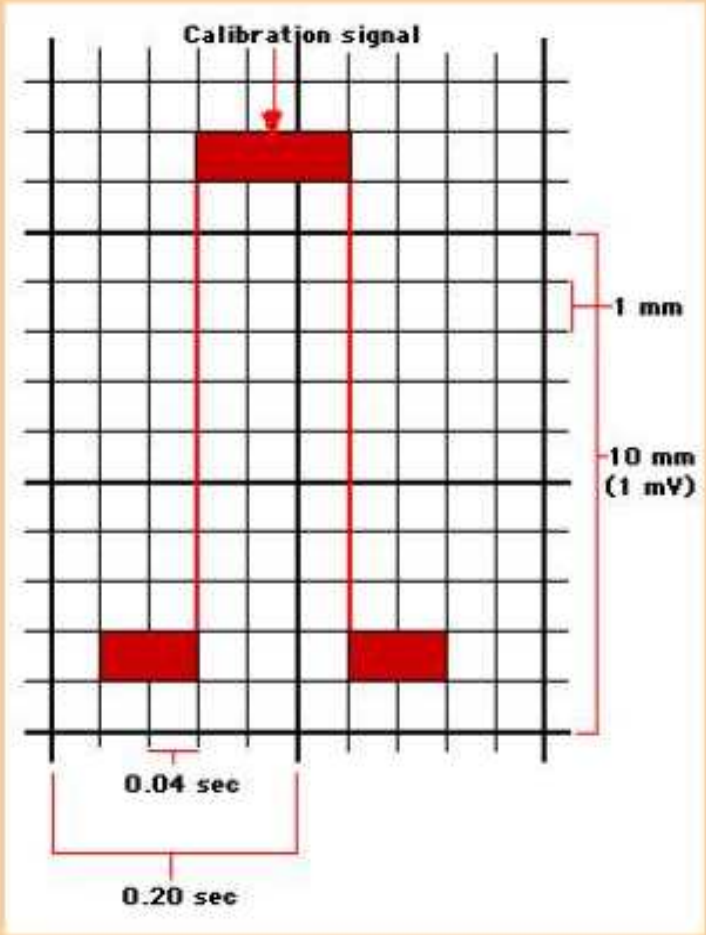
Arrangement of Leads on the ECG

I	aVR	V_1	V_4
II	aVL	V_2	V_5
III	aVF	V_3	V_6

Anatomic Groups

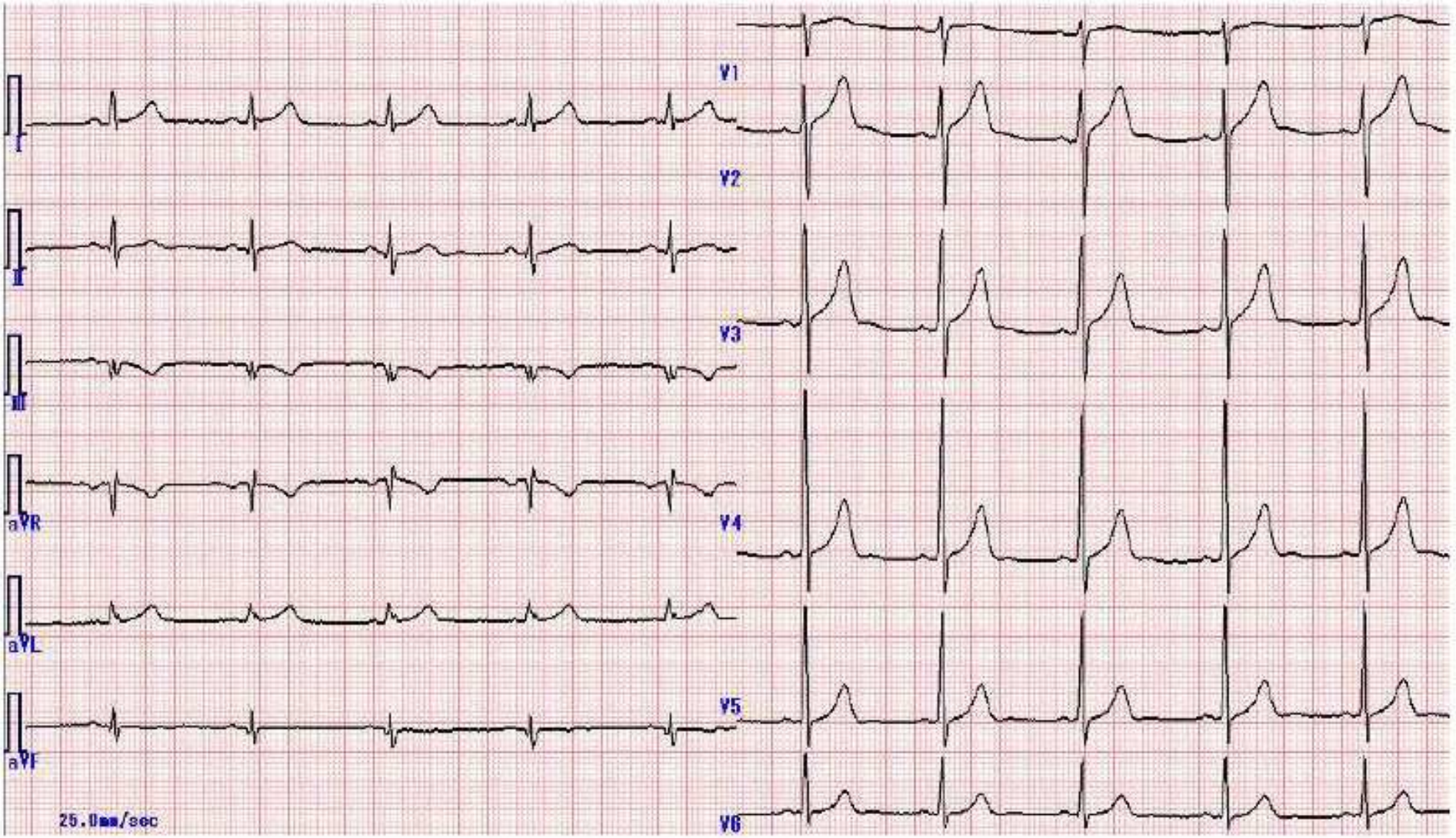
I Lateral	aVR None	V_1 Septal	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septal	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

Standard Paper Speed and Voltage



- Paper speed should be set at 25mm/sec
- Voltage should be set at 10mm = 1mV

Is the Voltage Standardized?
Is the Paper Speed Indicated?

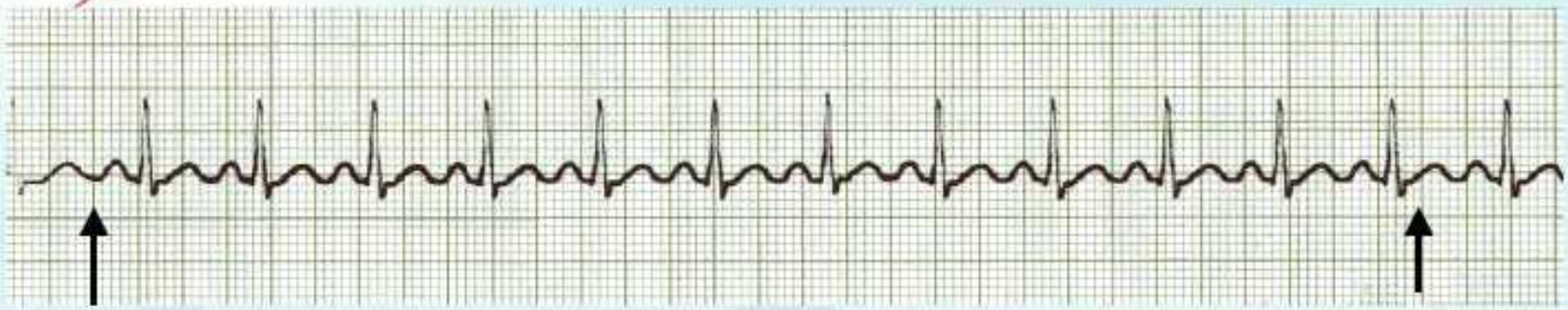


Heart Rate

measurements

Calculating the Heart Rate

NHS
Essex Cardiac Network



1) Count the number large squares between two consecutive 'R' waves
then divide the result by 300
i.e. 300/4 = 75 bpm

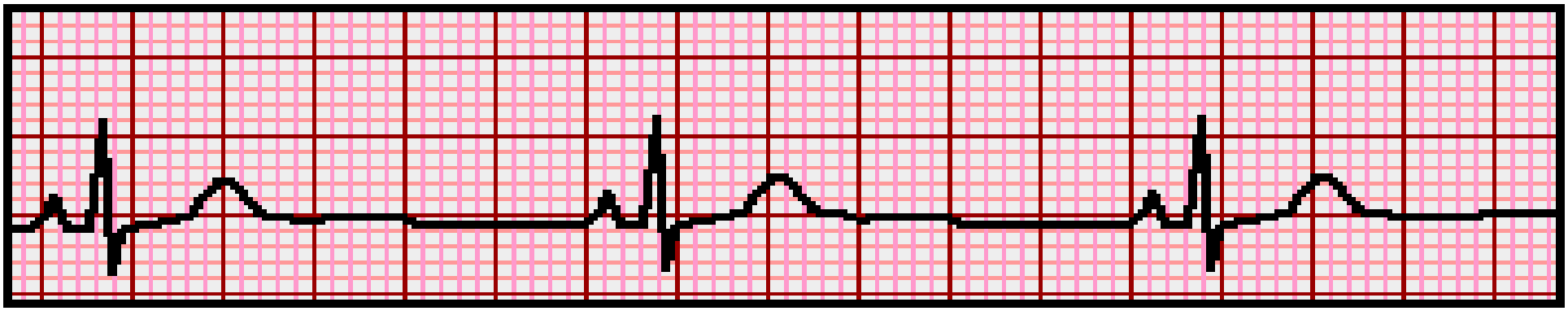
For regular H.R.

2) Count the number of 'R' waves in a 6 second strip (30 large squares)
then multiply the result by 10
i.e. 10 X 12 = 120 bpm
(this method is especially good for irregular heart rates)

15 cm

3) With a rate ruler

What is the heart rate?



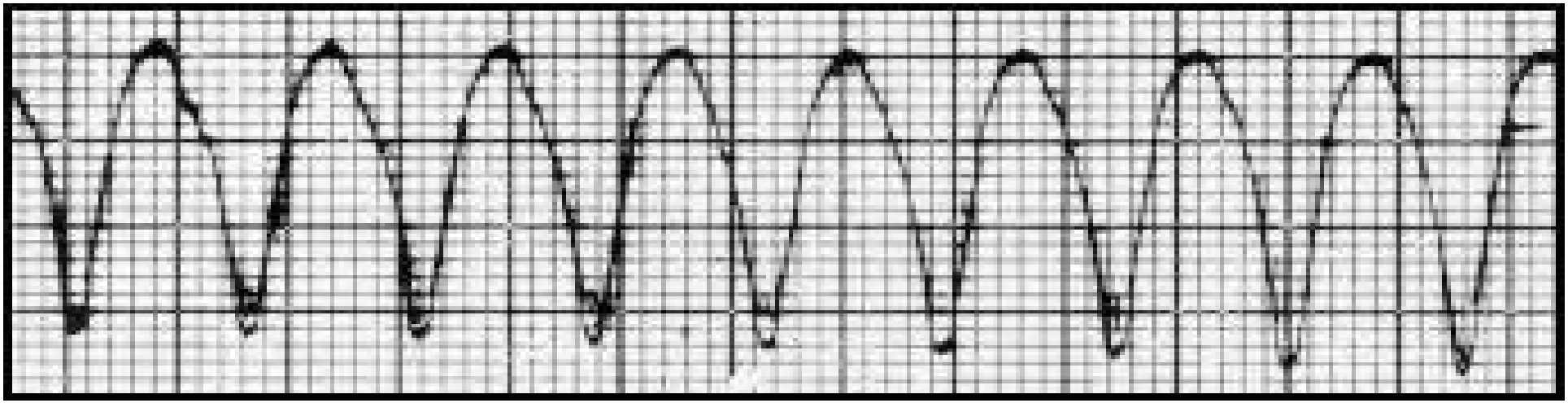
(300 / 6) = 50 bpm

What is the heart rate?



(300 / ~ 4) = ~ 75 bpm

What is the heart rate?



(300 / 1.5) = 200 bpm

What is the heart rate?



20 x 10 = 200 bpm

Normal H.R. 60-90 bpm
Bradycardia less than 60 bpm
Tachycardia less than 100 bpm

Rhythm

What is the Rhythm ?

- Is there a p wave in front of every QRS complex?
- Is every p wave followed by a QRS complex?
- Do the p waves all look the same?
- Is the rhythm regular? Regularly irregular? Irregularly irregular?
- Are the QRS complexes narrow, wide or a mixture of the two?

Is there a p wave in front of every QRS?

yes



Are they all normal sinus p waves?

yes



Normal sinus rhythm

Is every p wave followed by a QRS complex?



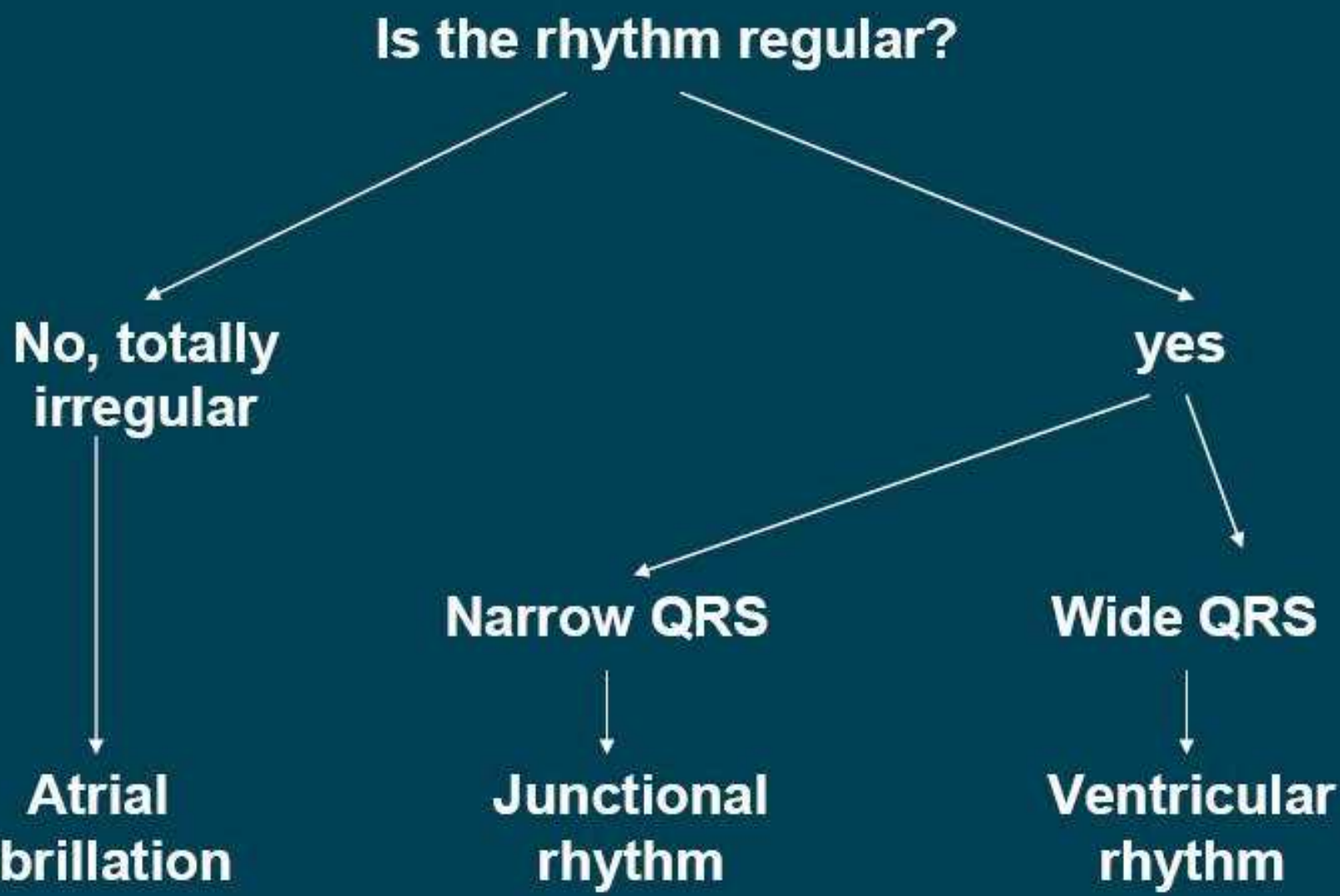
Some p waves are blocked

Blocked p wave premature?

Blocked PAC

Second or third degree heart block

No p waves at all?



Wide QRS beat?

- If preceded by a sinus p wave at the appropriate PR interval, this is a sinus beat which is wide due to a block in the left or right bundle

- If no p wave, beat originates in the ventricle either prematurely (PVC) or because no other beat came along (ventricular escape beat)

Wide QRS Beats



Wide QRS with a p wave Bundle Branch Block



Wide QRS with no p wave Ventricular beat

Regular rhythm

- If H.R. is normal (normal , atrial flutter)
- If bradycardia

no P or inverted (nodal rhythm)

normal P

@ regular relation with QRS (complete HB, sinus bradycadia)

@ irregular relation with QRS (partial HB)

If tachycardia

Abnormal QRS (vent . Tachycardia)

normal QRS

@ Normal P (SVT atrial)

@absent or inverted P (SVT nodal)

Irregular rhythm

- If irregular irregularity (AF)
- If occasional irregularity

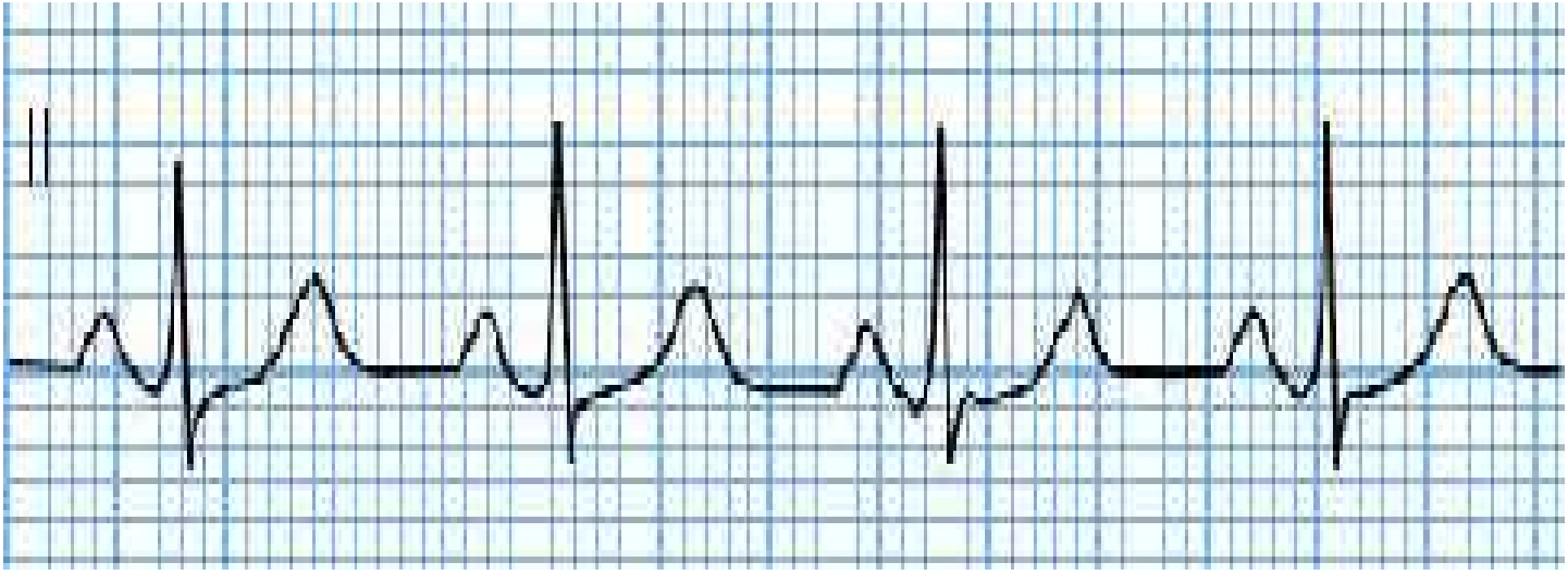
  # normal QRS (Supravent. extrasystole)

  # abnormal ORS (Vent. Extrasystole)

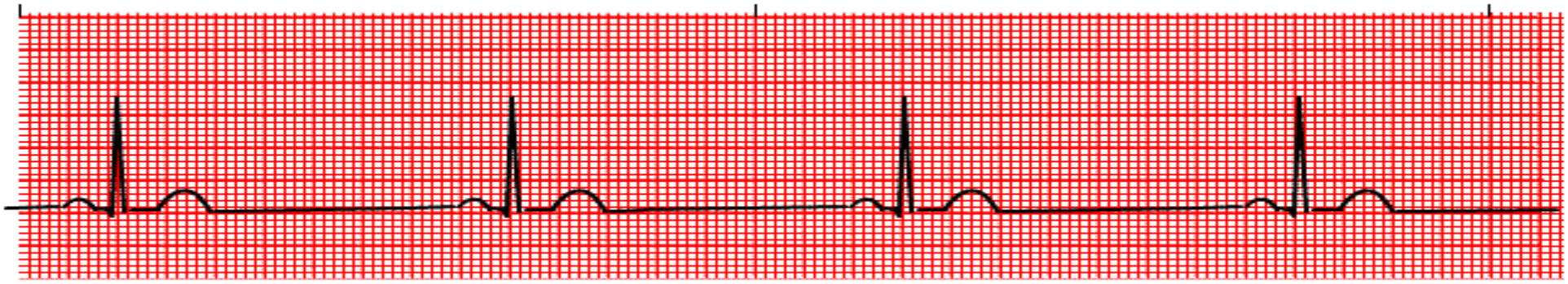
Normal Sinus Rhythm – the rules!

- P before every QRS
- PR interval <0.2 seconds (5 baby squares)
- QRS after every P wave
- QRS <0.12 seconds (3 baby squares)
- Regular and identical
- Rate 60-100 bpm
  - <60 bpm – sinus bradycardia
  - >100 bpm – sinus tachycardia

Sinus rhythm

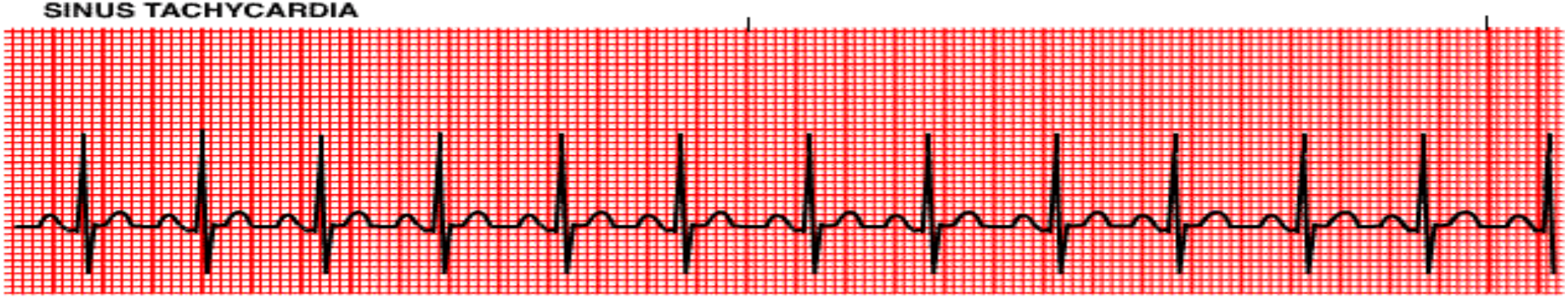


SINUS BRADYCARDIA



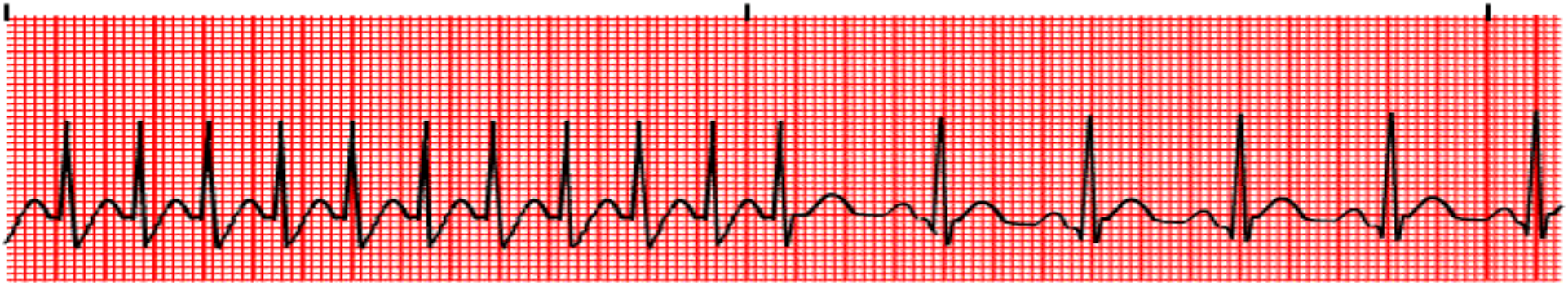
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SINUS TACHYCARDIA



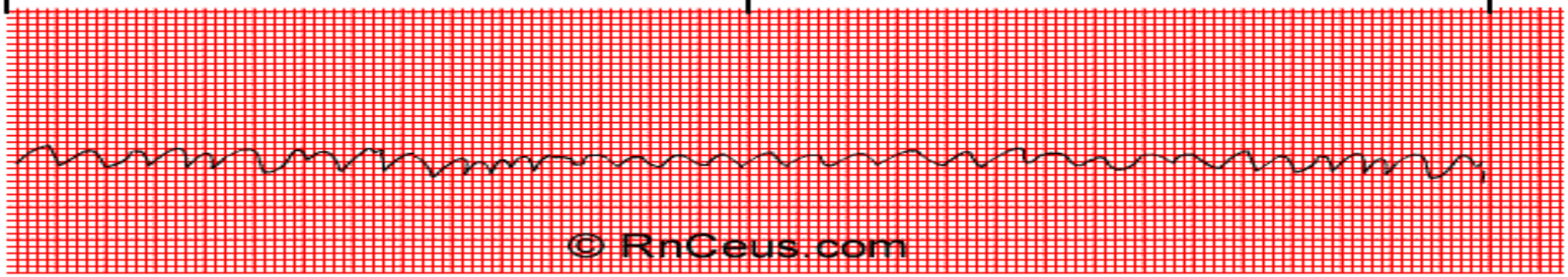
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PAROXYSMAL ATRIAL TACHYCARDIA

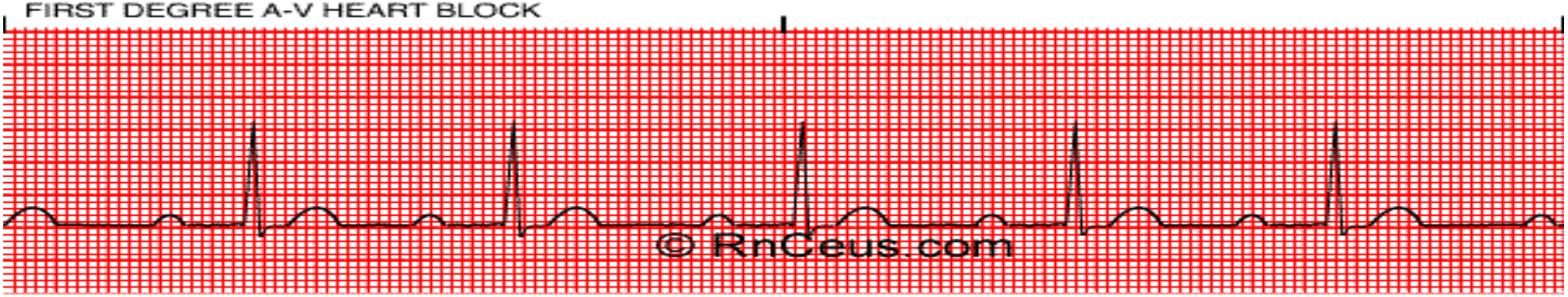


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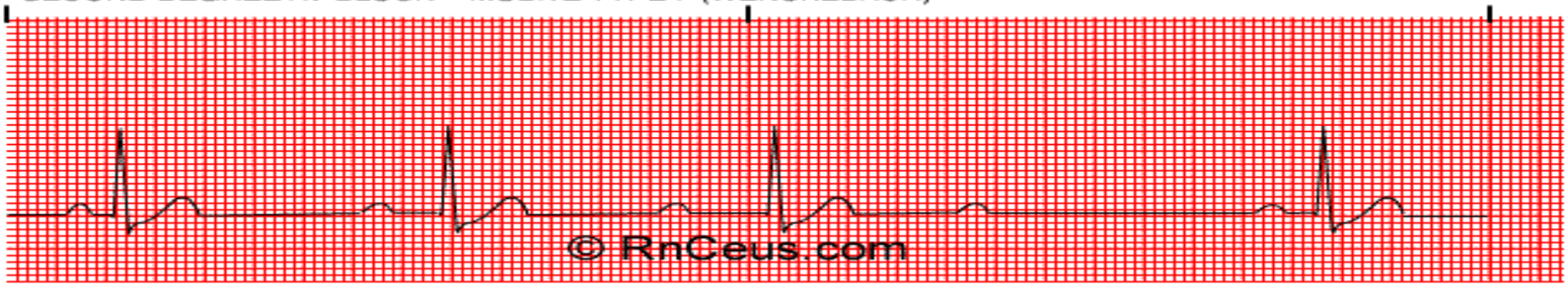
VENTRICULAR FIBRILLATION



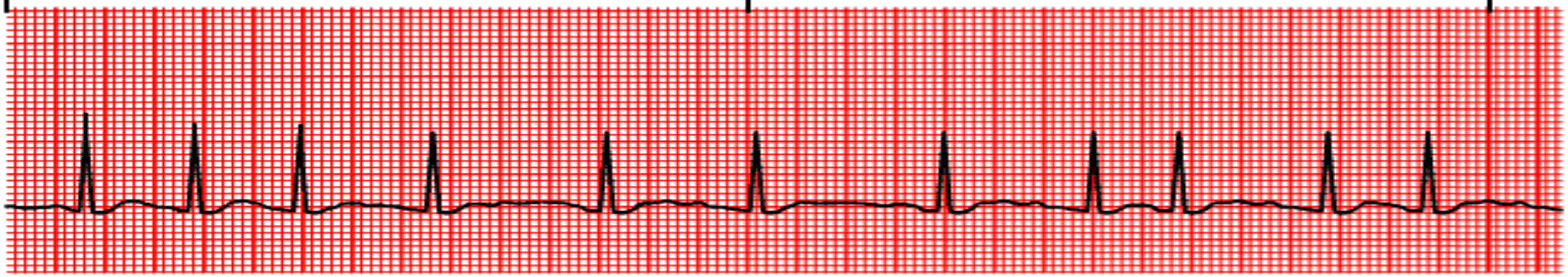
FIRST DEGREE A-V HEART BLOCK



SECOND DEGREE AV BLOCK - MOBITZ TYPE I (WENCKEBACH)

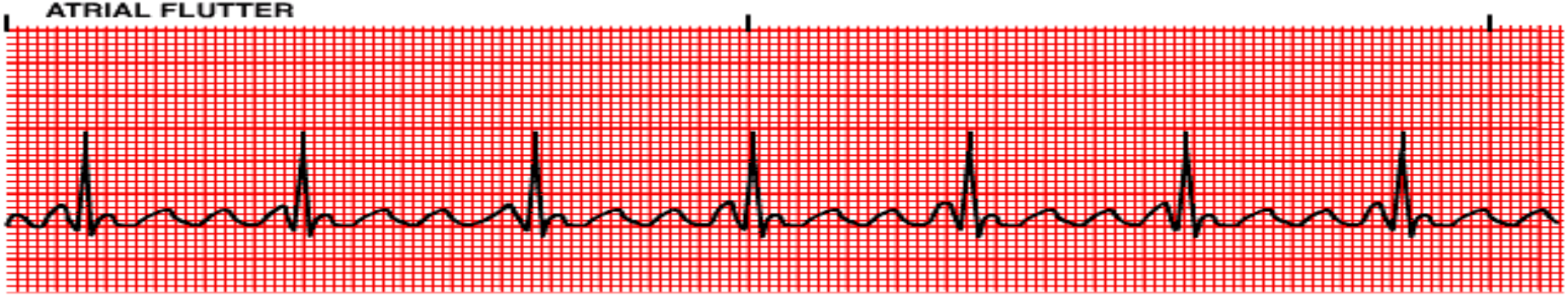


ATRIAL FIBRILLATION



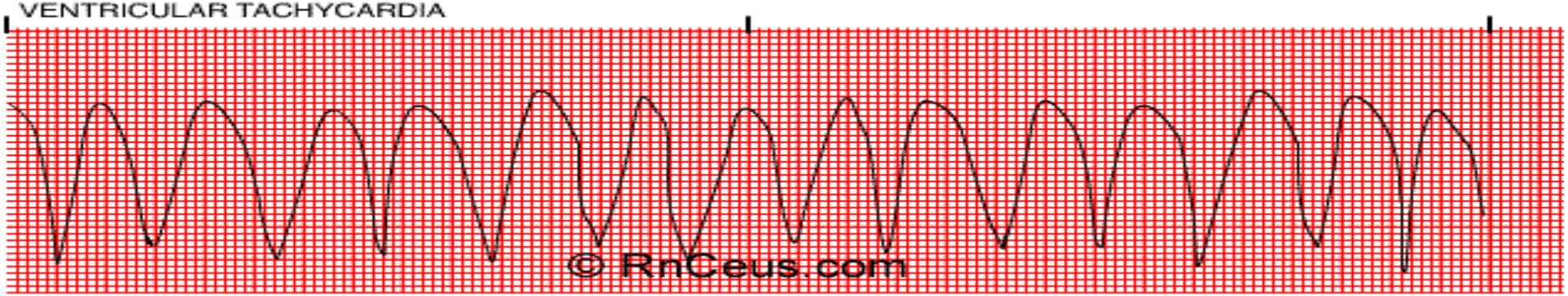
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ATRIAL FLUTTER

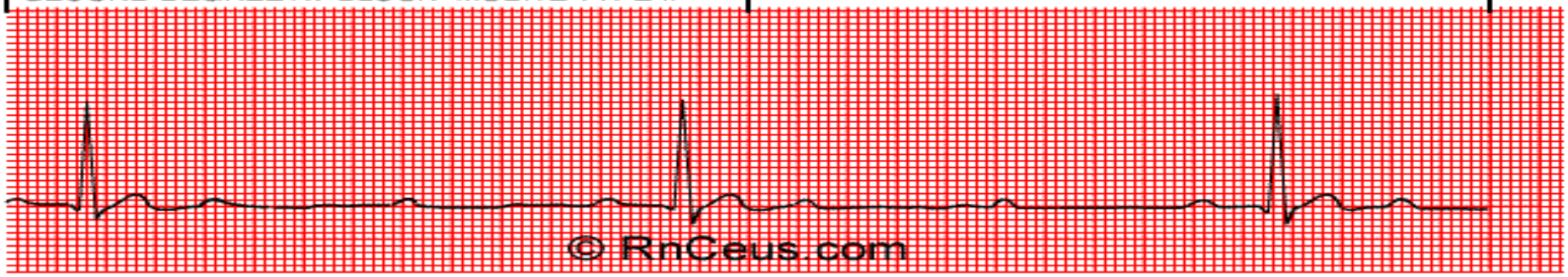


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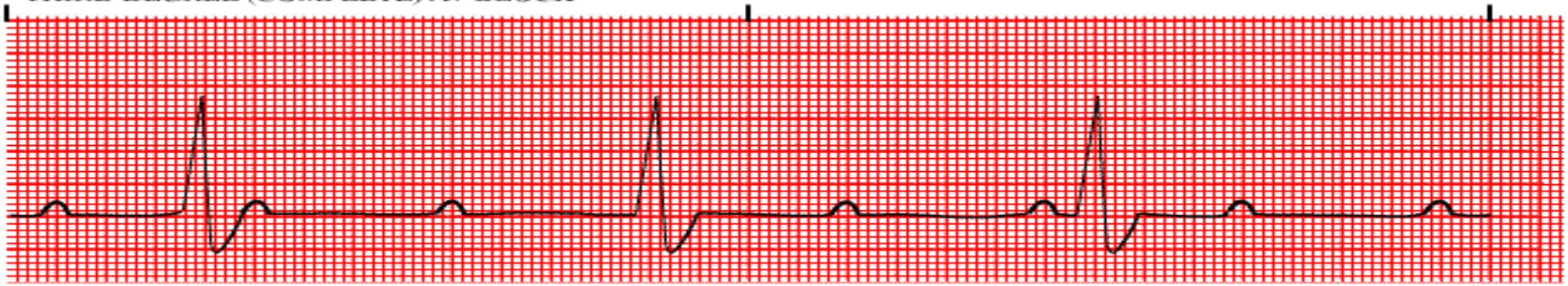
VENTRICULAR TACHYCARDIA



SECOND DEGREE AV BLOCK- MOBITZ TYPE II

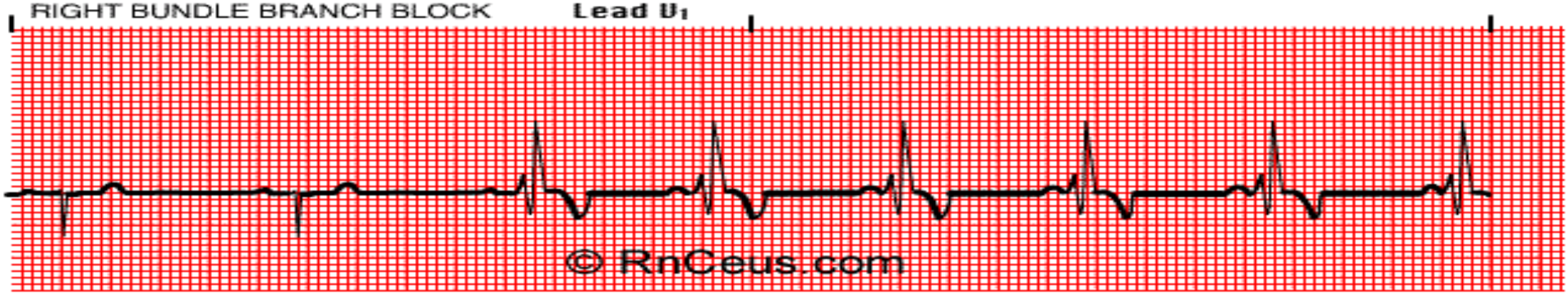


THIRD DEGREE (COMPLETE) AV BLOCK

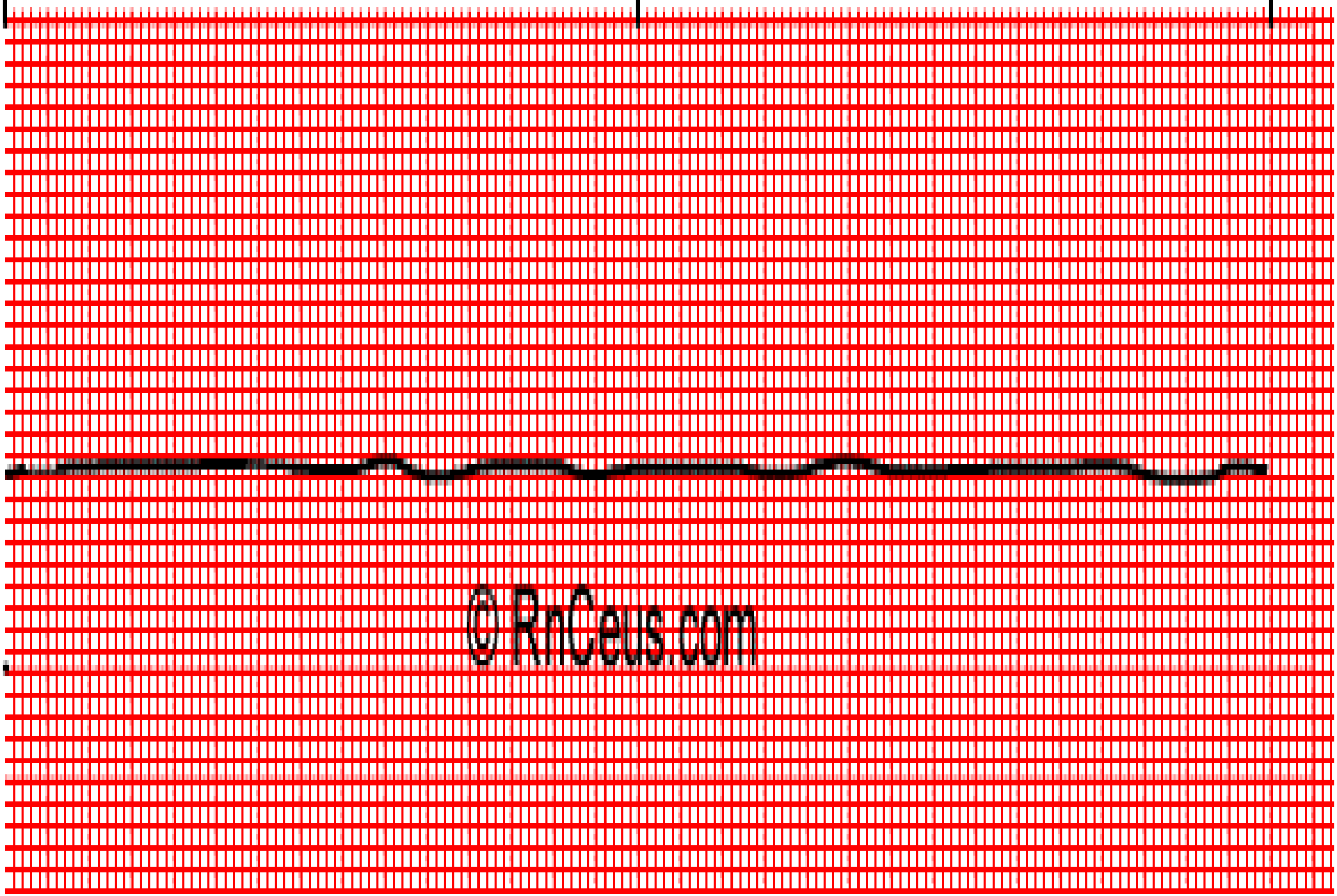


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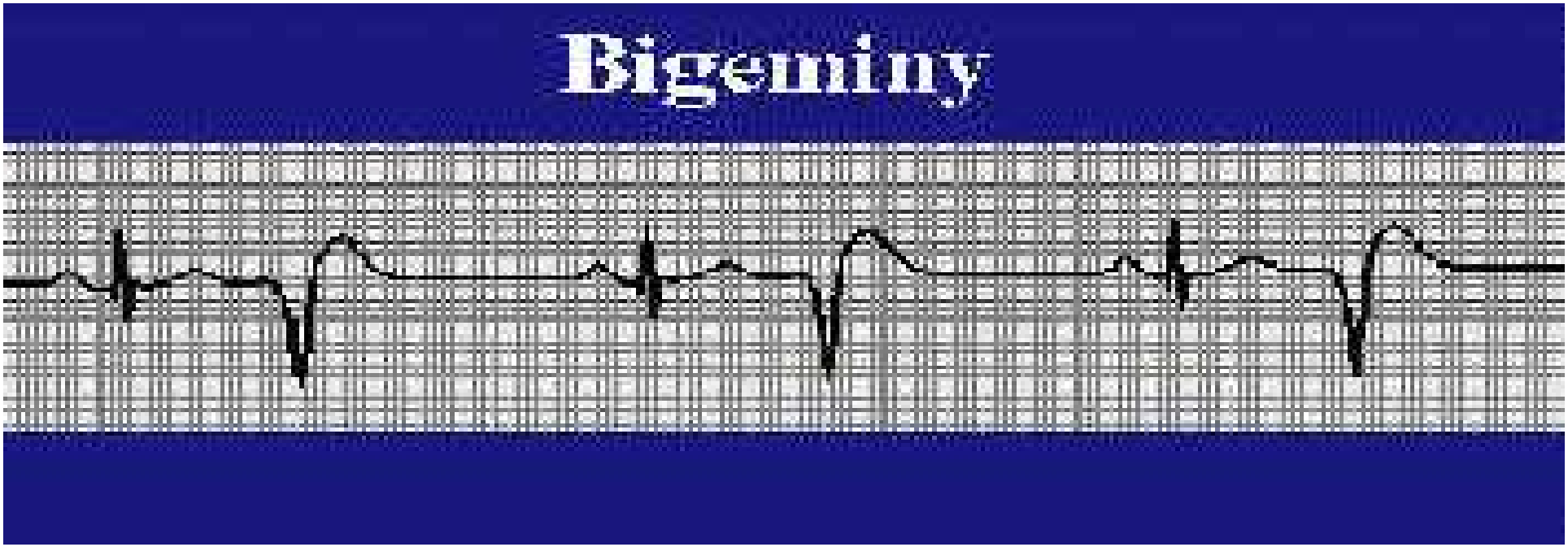
RIGHT BUNDLE BRANCH BLOCK Lead V_1



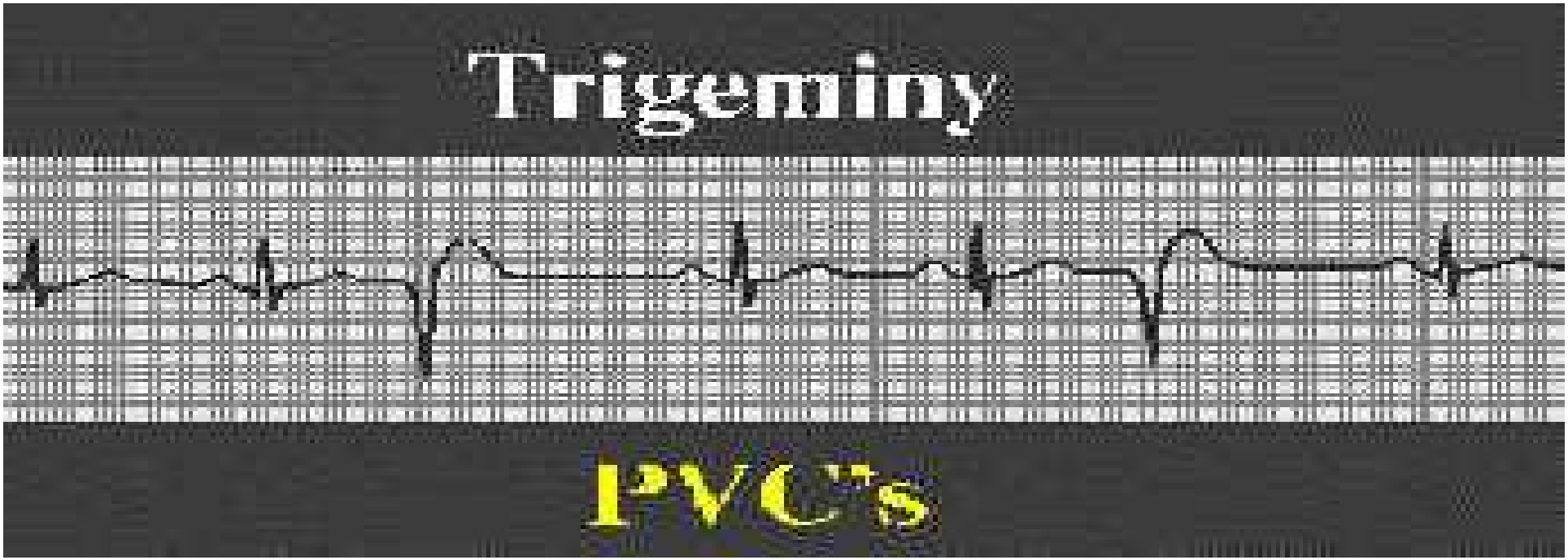
VENTRICULAR STANDSTILL (Asystole)



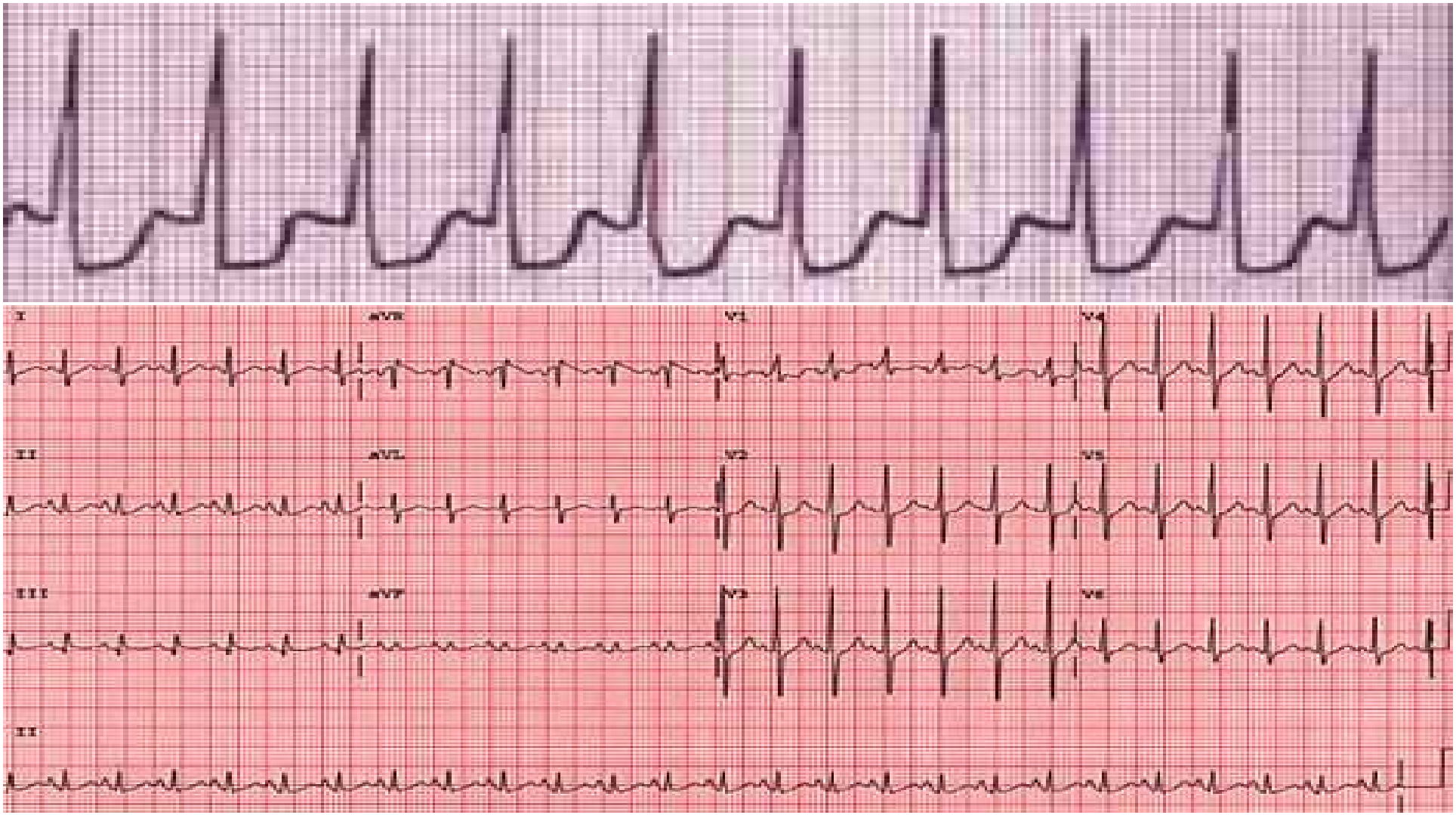
Bigeminy VPC



Trigeminy VPC



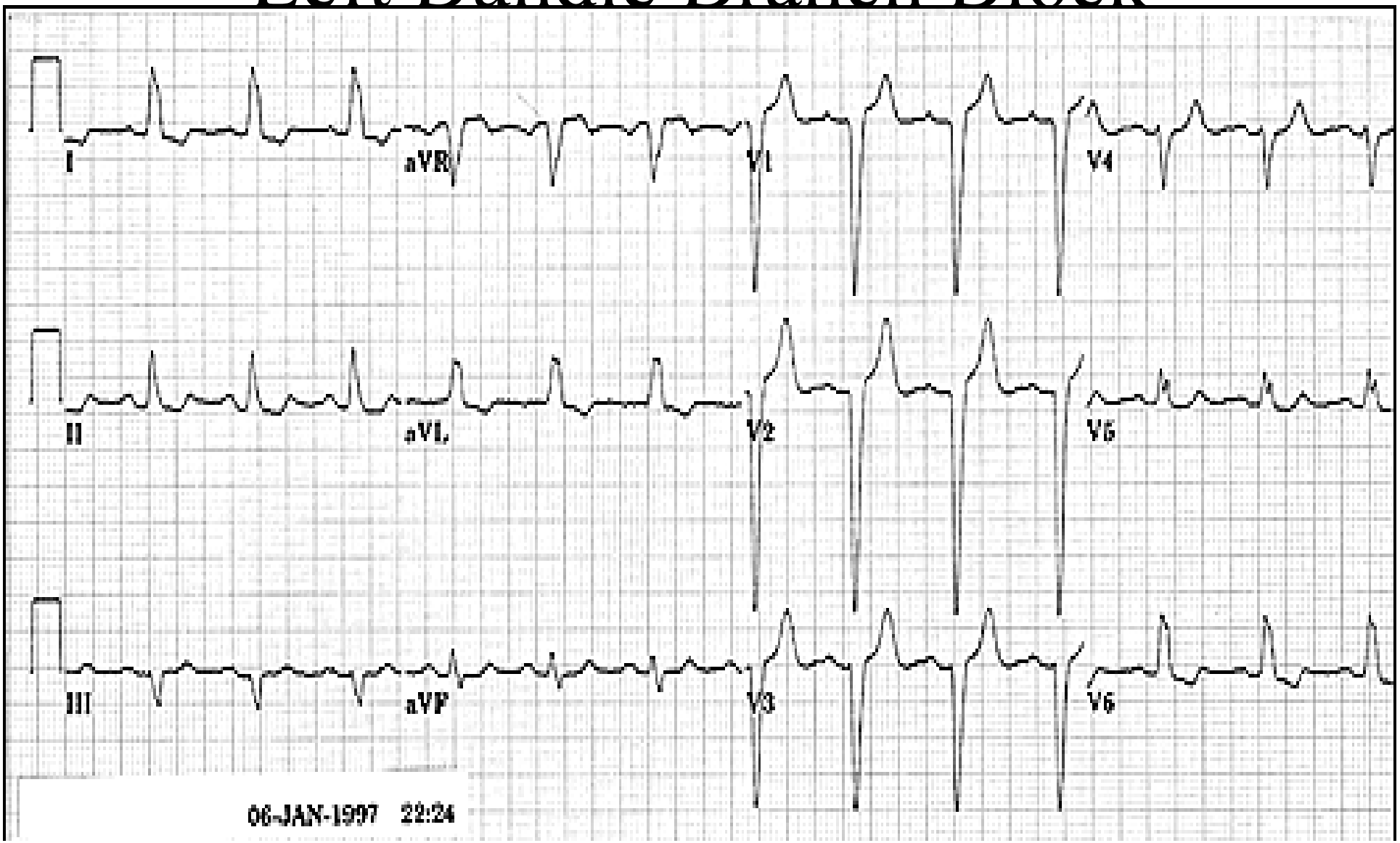
PSVT



Left Bundle Branch Block Criteria

- QRS duration $\geq$ 120ms
- Broad R wave in I and V_6
- Prominent QS wave in V_1
- Absence of q waves (including physiologic q waves) in I and V_6

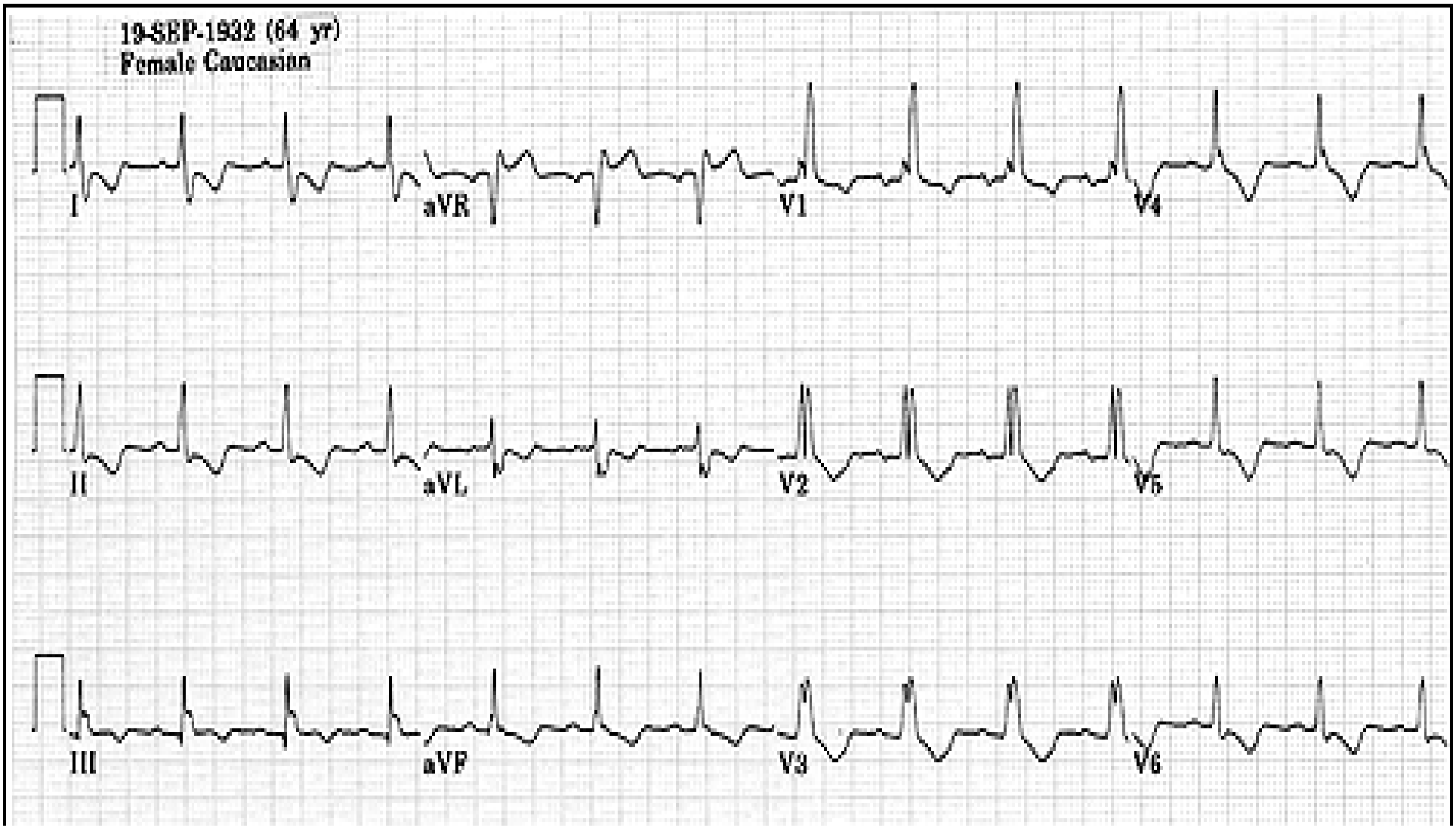
Left Bundle Branch Block



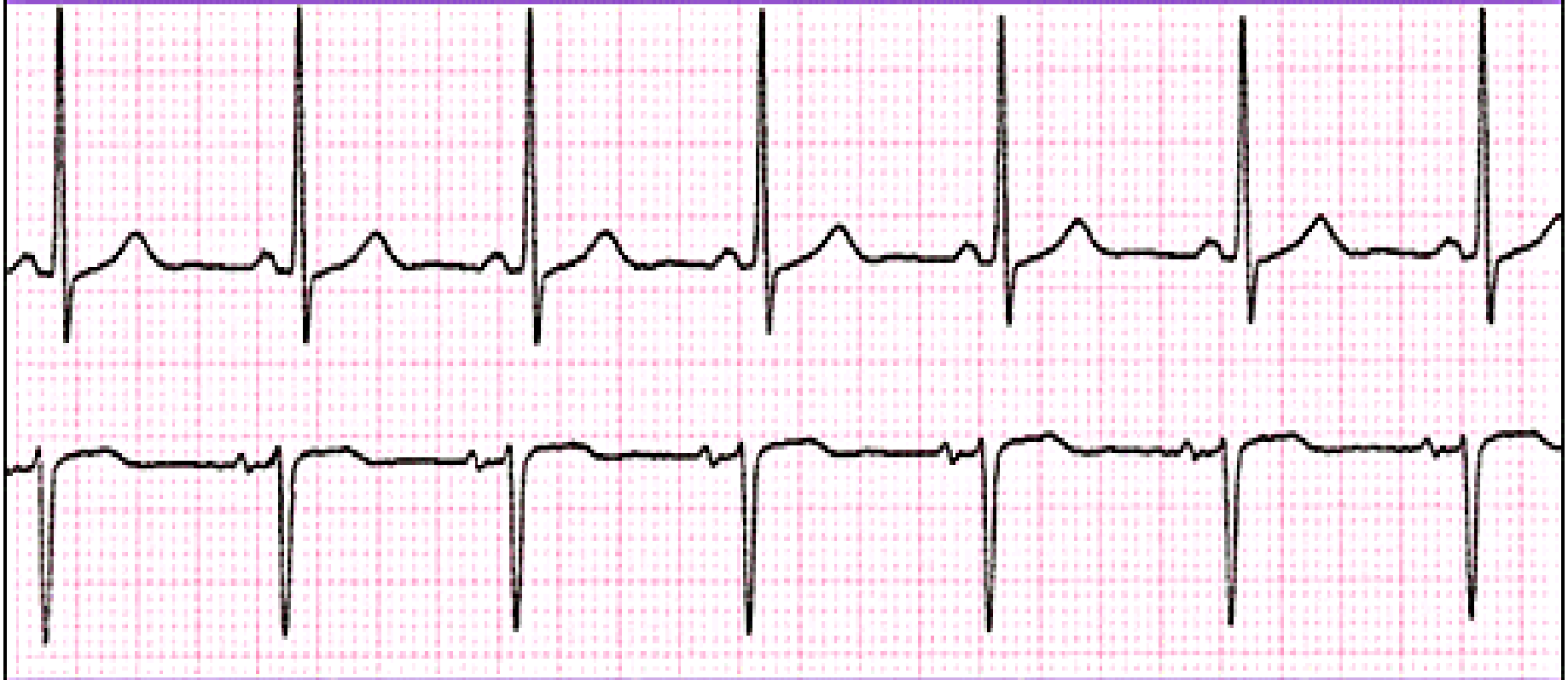
Right Bundle Branch Block Criteria

- QRS duration $\geq$ 110ms
- rSR' pattern or notched R wave in V_1
- Wide S wave in I and V_6

Right Bundle Branch Block

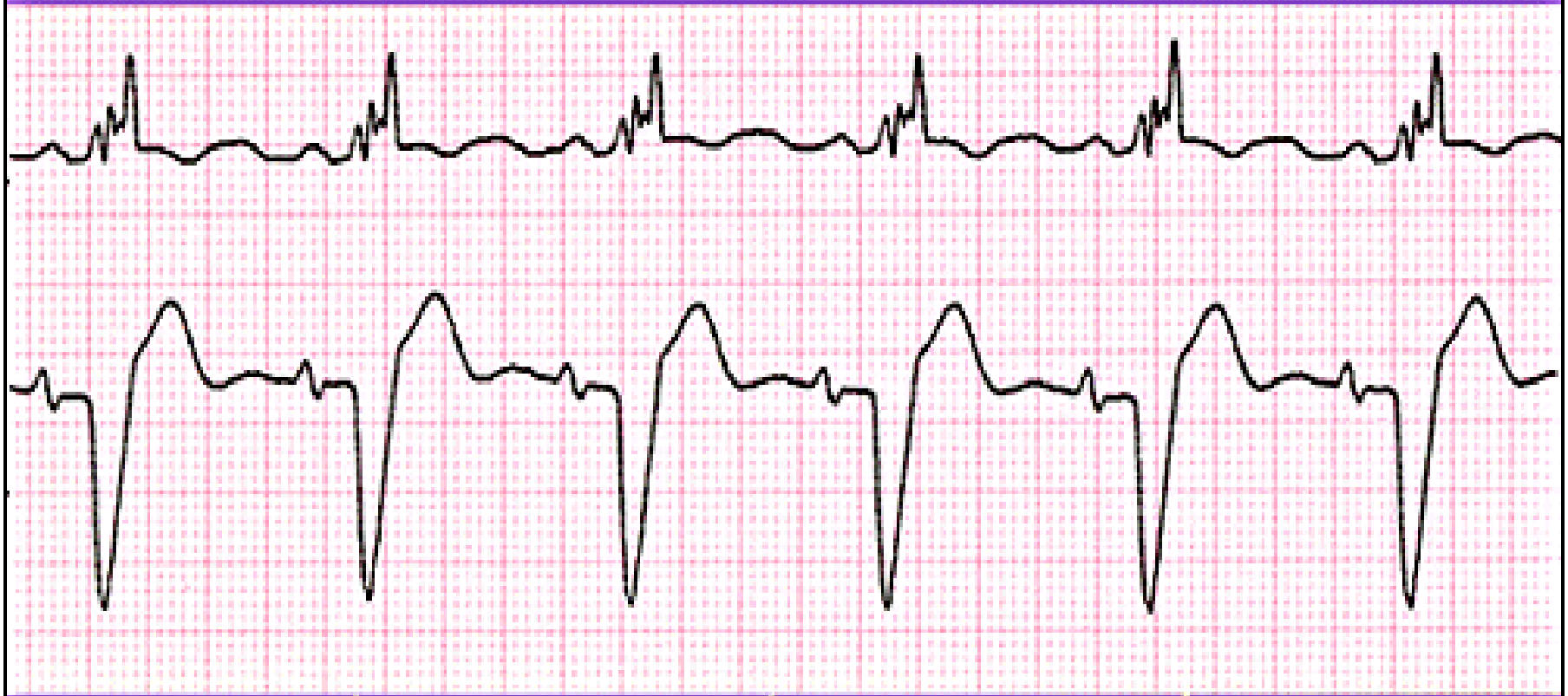


Normal Sinus Rhythm



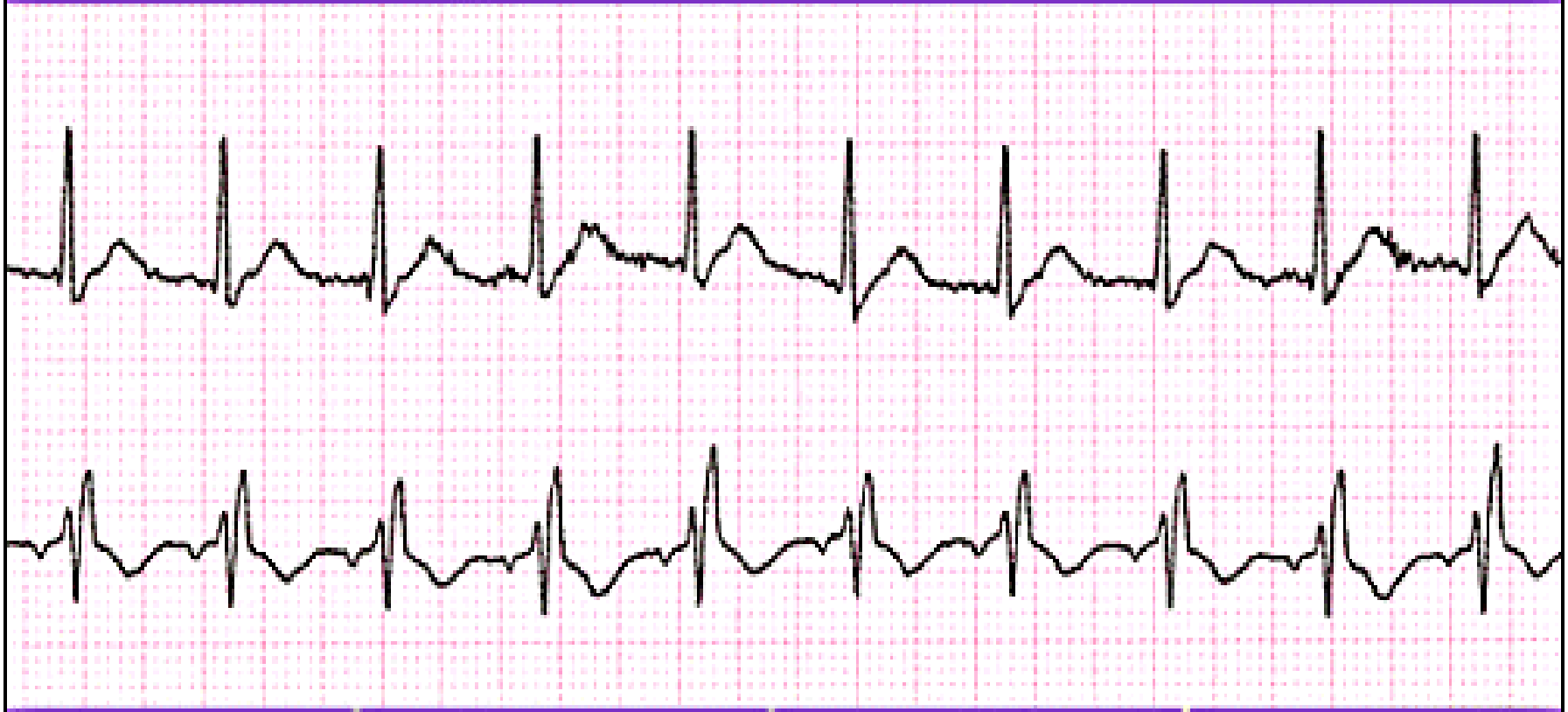
Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
60-100 bpm	Regular	Before each QRS, identical	.12 to .20	<.12

Left Bundle Branch Block



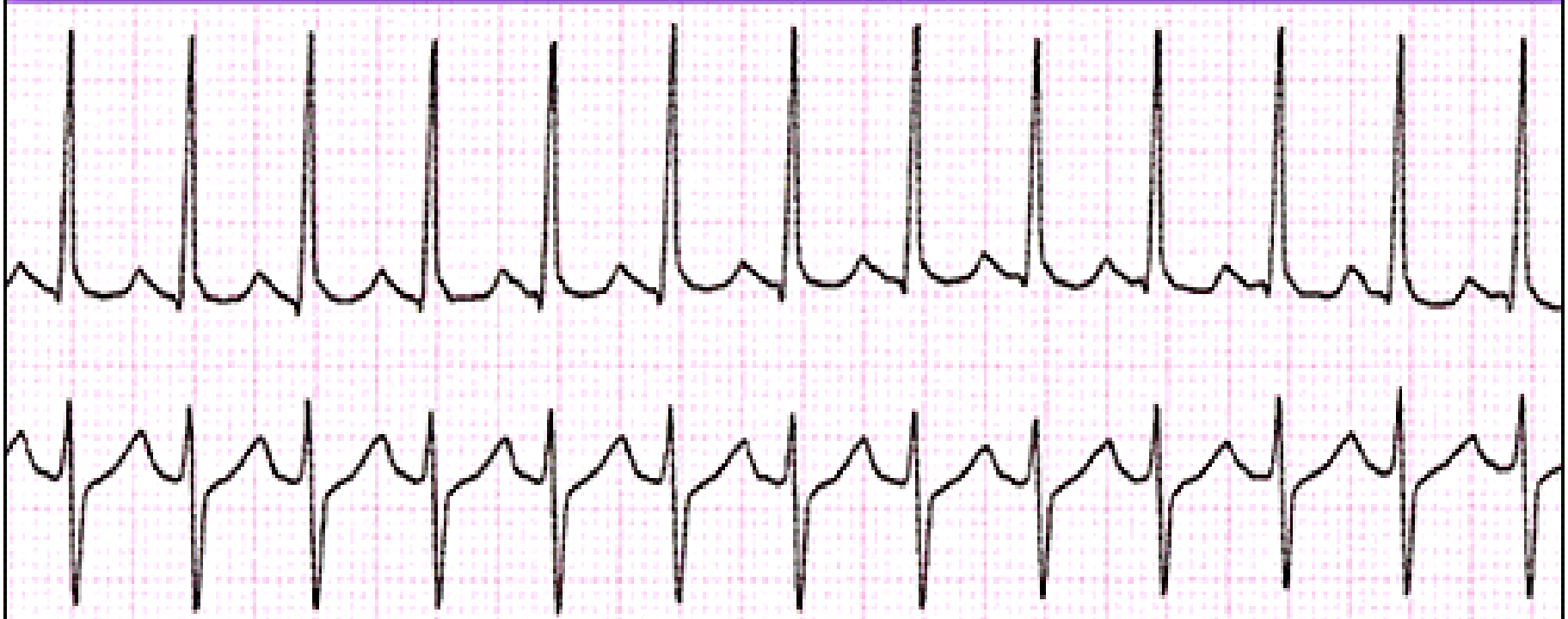
P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	.12 to .20	≥.12	RR' in V5

Right Bundle Branch Block



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	.12 to .20	>.12	RSR' in V1

Atrial Tachycardia



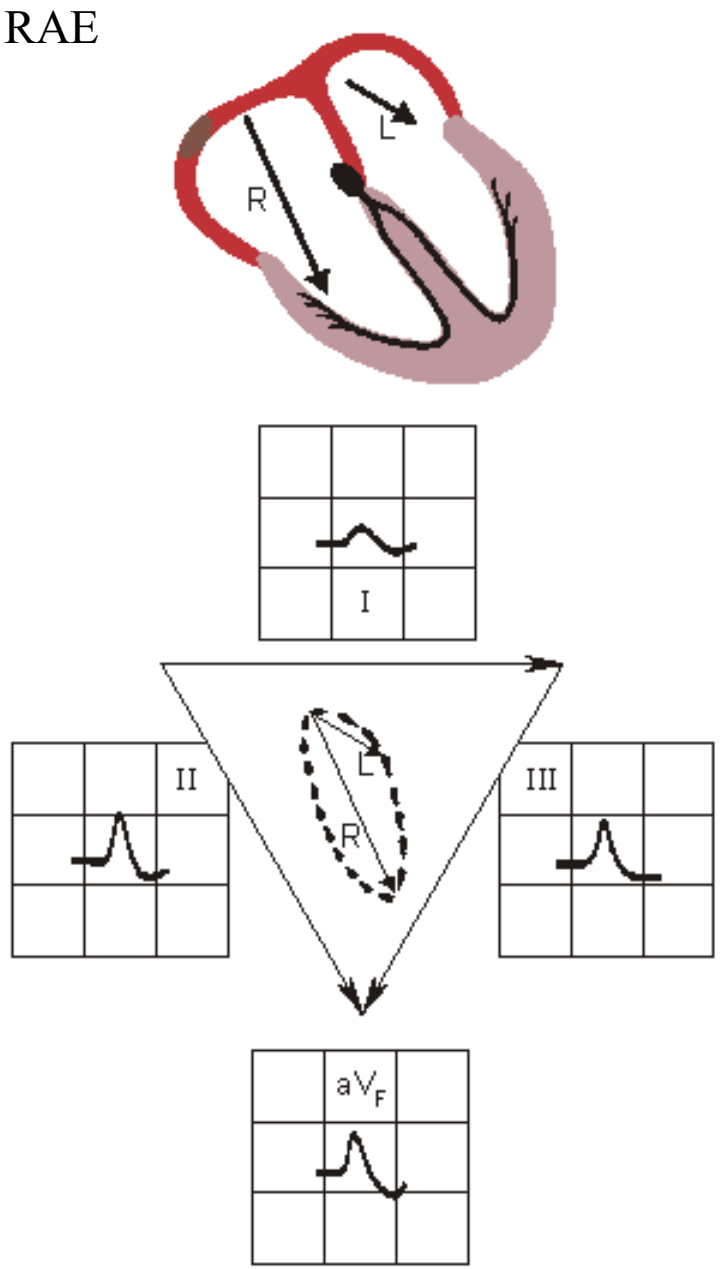
Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
140-250 bpm	Regular	Abnormal P before each QRS (difficult to see)	<.20	<.12

P wave

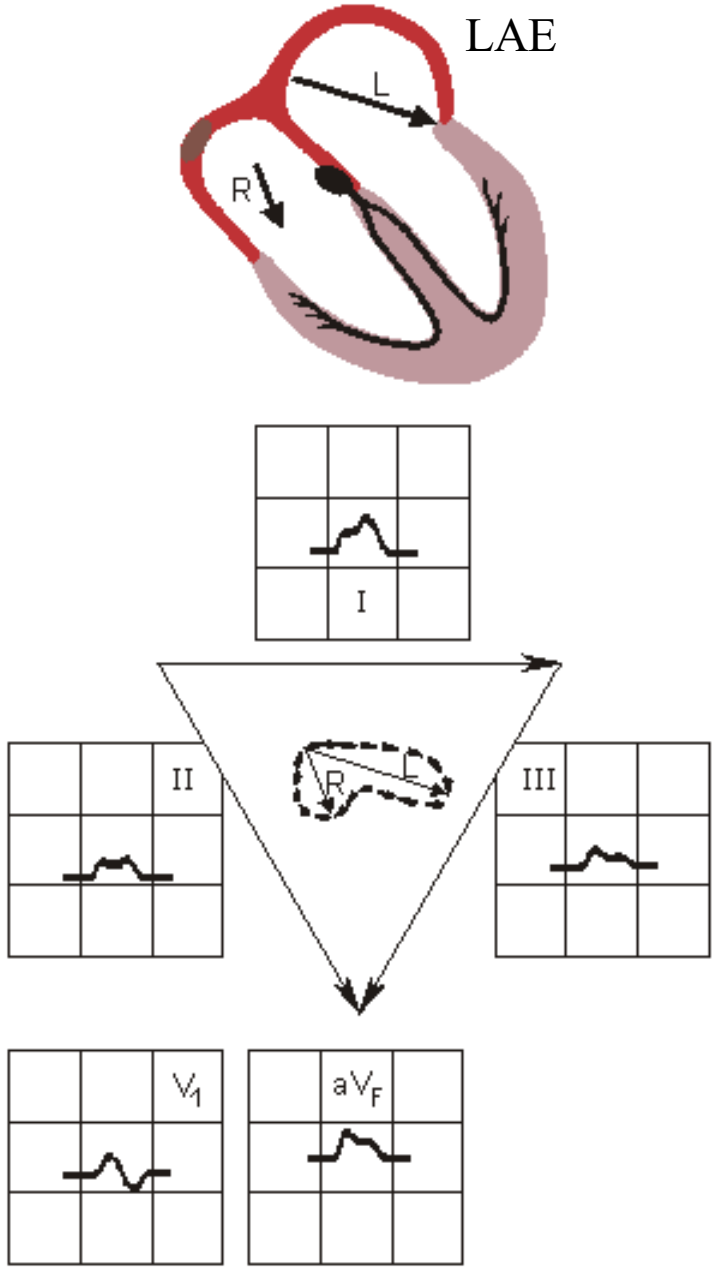
P waves

- It is important to remember that the P wave represents the *sequential* activation of the right and left atria, and it is common to see notched or biphasic P waves of right and left atrial activation.
- Does not exceed 2.5 mm (height) in lead II
- Less than 0.12 seconds (width) in lead II
- Abnormal P:
  - RAE (P Pulmonale)
  - LAE (P mitrale)
  - Atrial flutter
  - Nodal rhythm (absent with regular rhythm)
  - AF(absent with irregular rhythm)
  - Dextrocardia

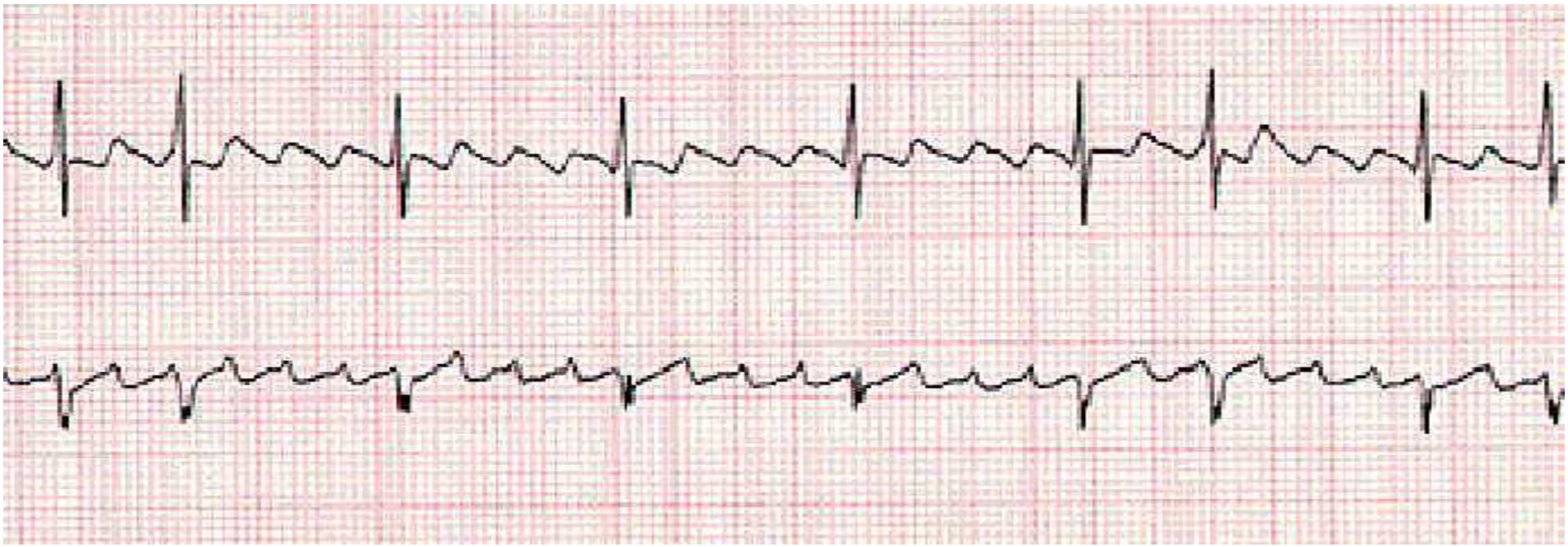
RAE



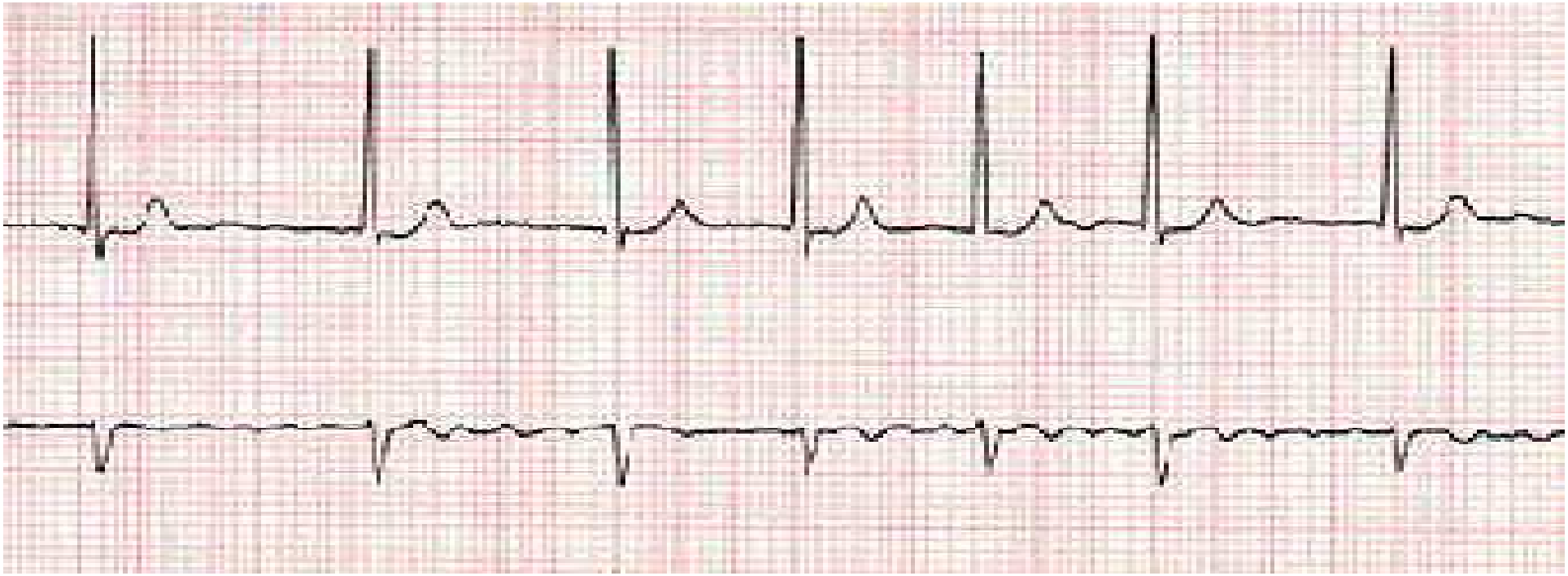
LAE



Atrial flutter



Atrial fibrillation



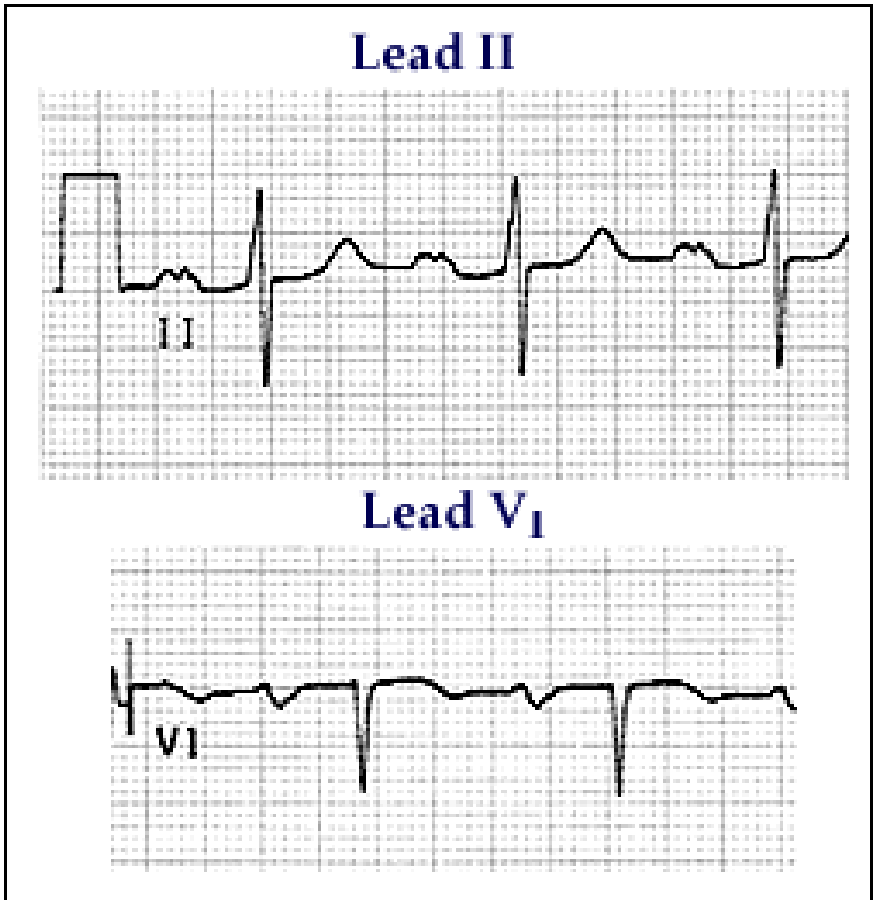
Left Atrial Enlargement

Criteria

P wave duration in II ≥120ms

or

Negative component of biphasic P wave in V_1 ≥ 1 "small box" in area



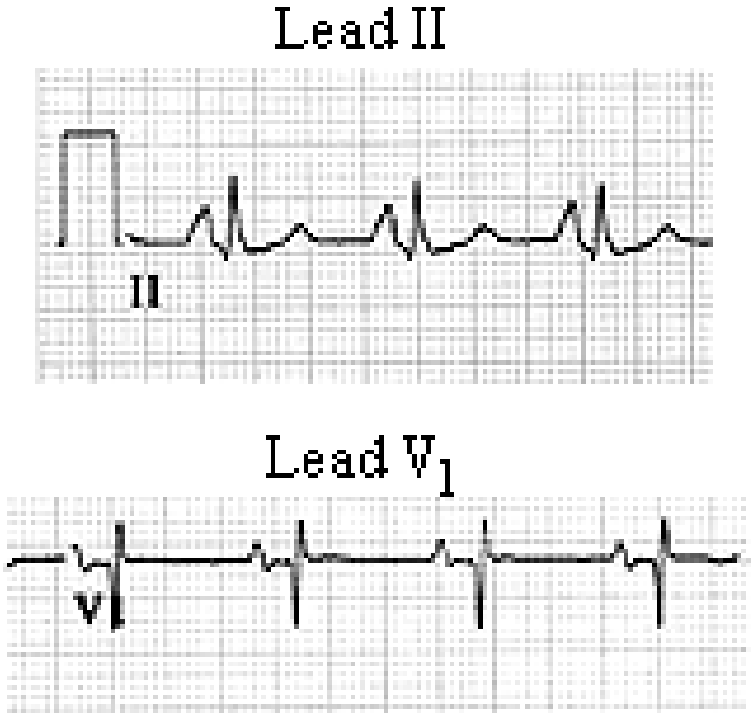
Right Atrial Enlargement

Criteria

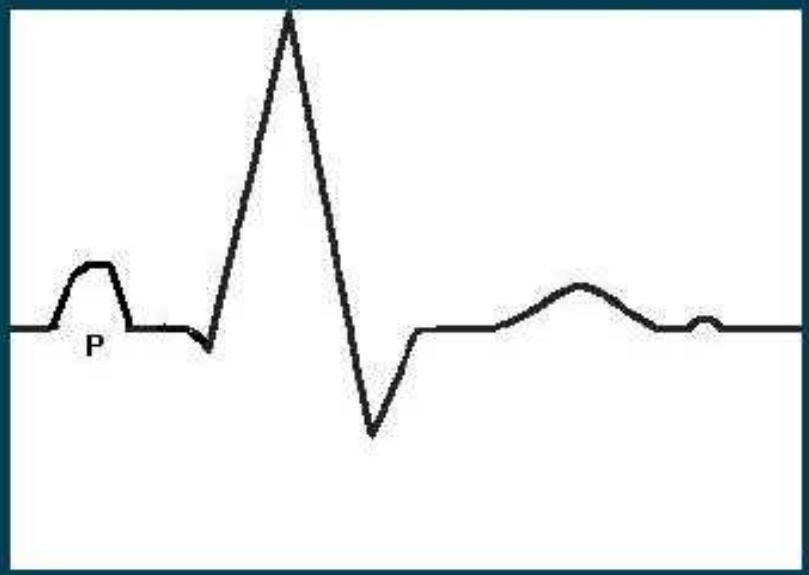
P wave height in II ≥ 2.4mm

or

Positive component of biphasic P wave in V_1 ≥ 1 "small box" in area



The P Wave Represents Atrial Depolarization



- Right atrial enlargement results in tall p waves, best seen in leads II, III, and aVF

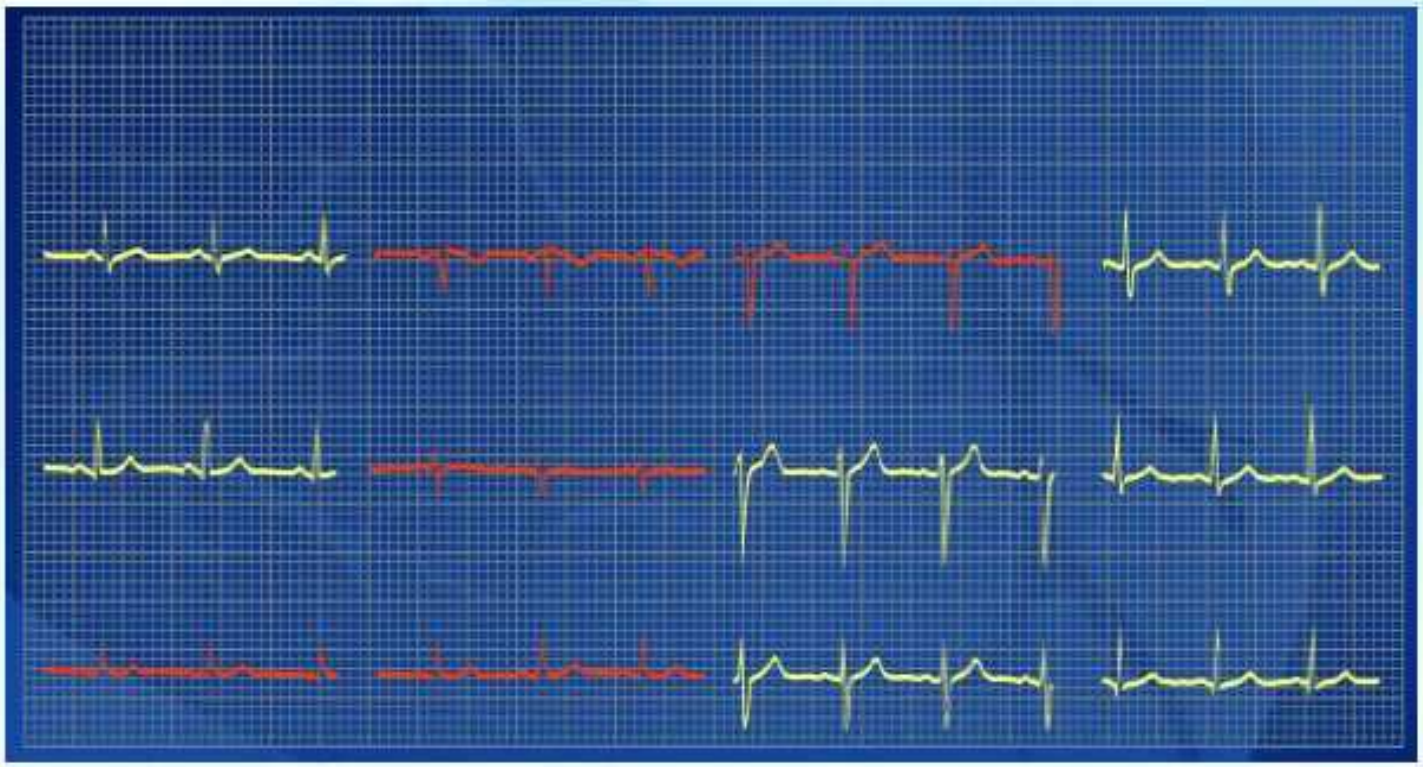


- Left atrial enlargement leads to a double hump or “m”shaped p wave

Rule 8

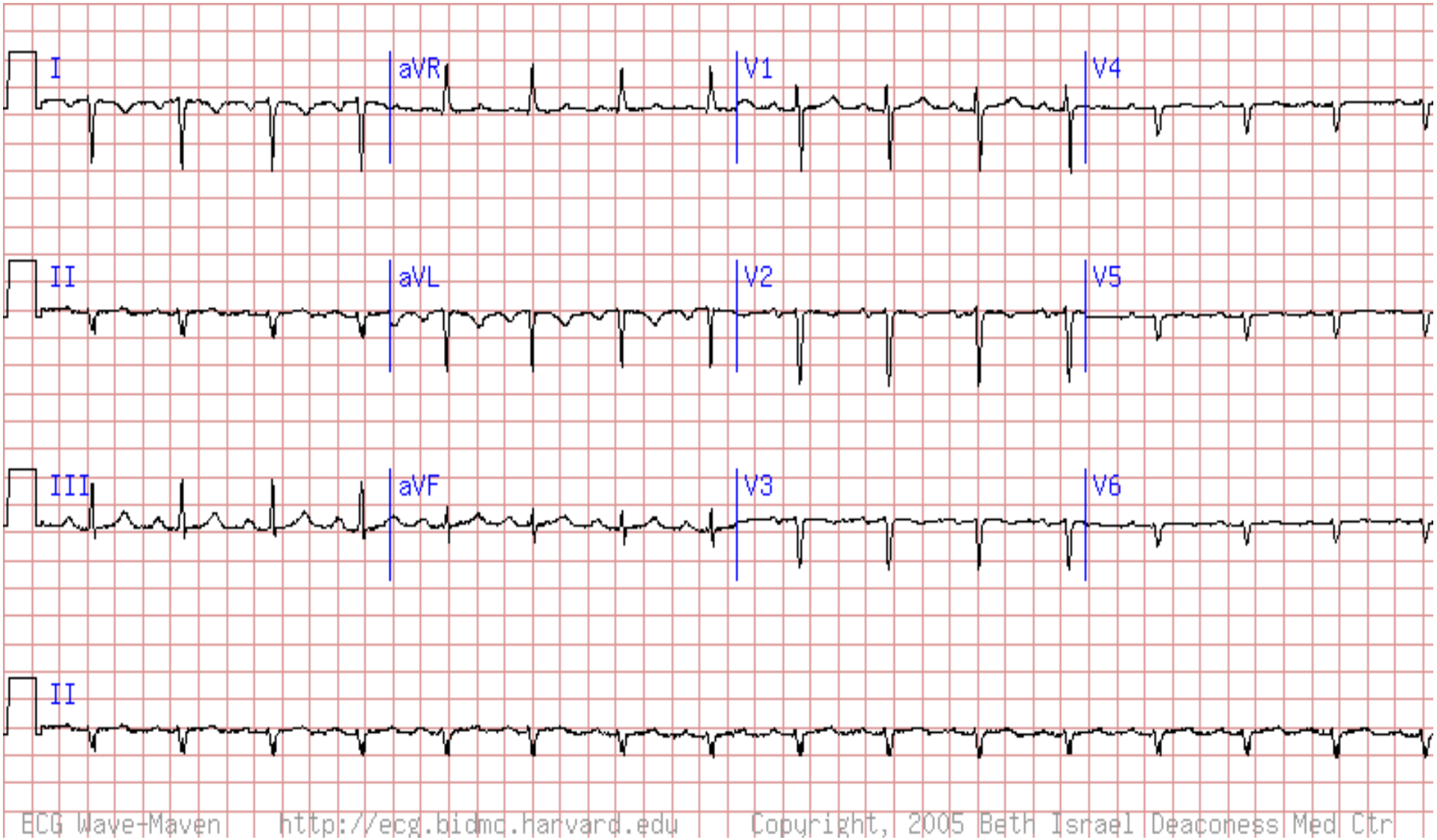
NHS

Essex Cardiac Network



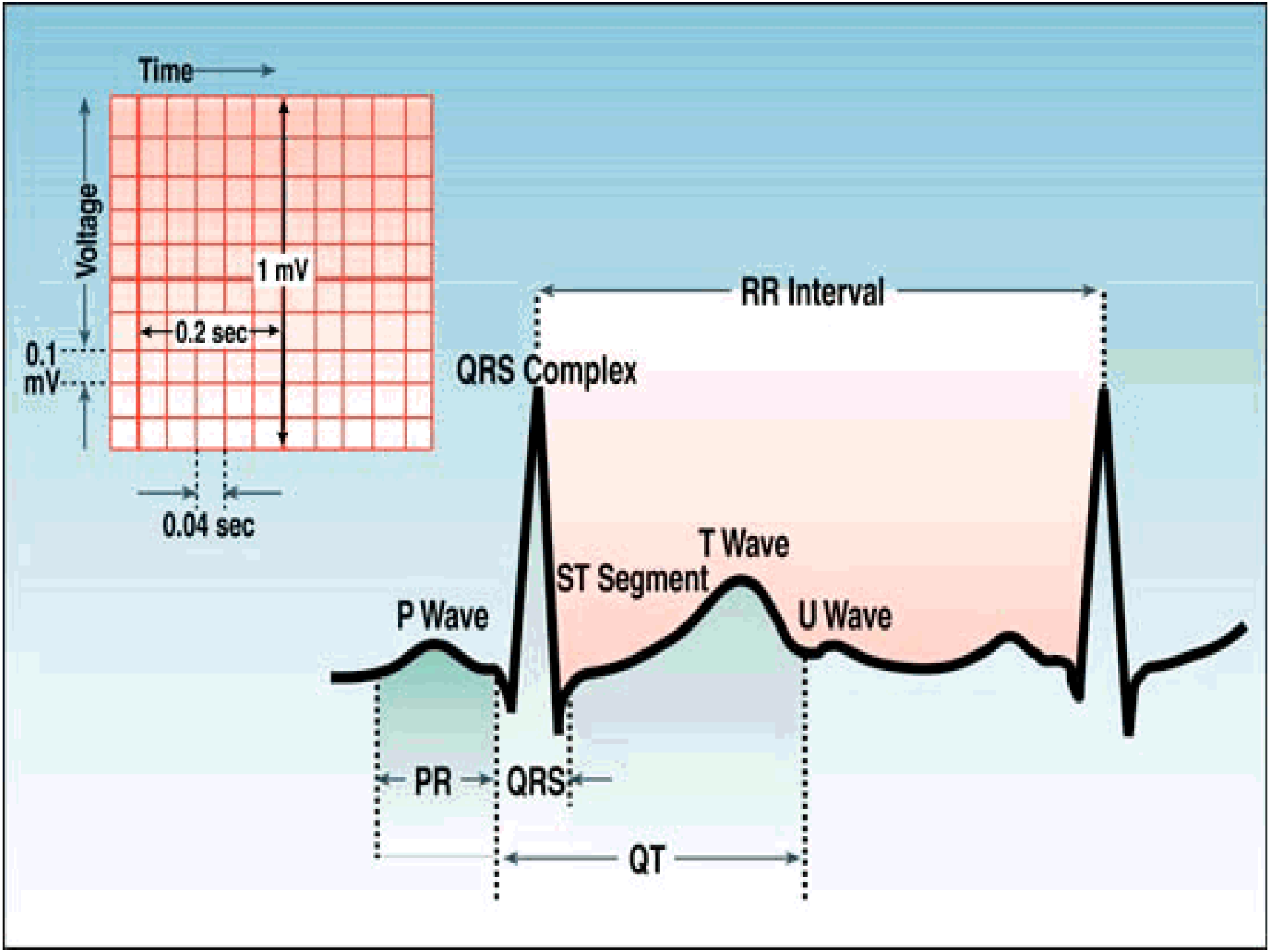
The P waves should be upright in I, II, and V2 to V6

Dextrocardia



PR Interval

Look at it !


Time
Voltage
1 mV
0.2 sec
0.1 mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
U Wave
PR
QRS
QT

PR interval

- measured from beginning of P to beginning of QRS

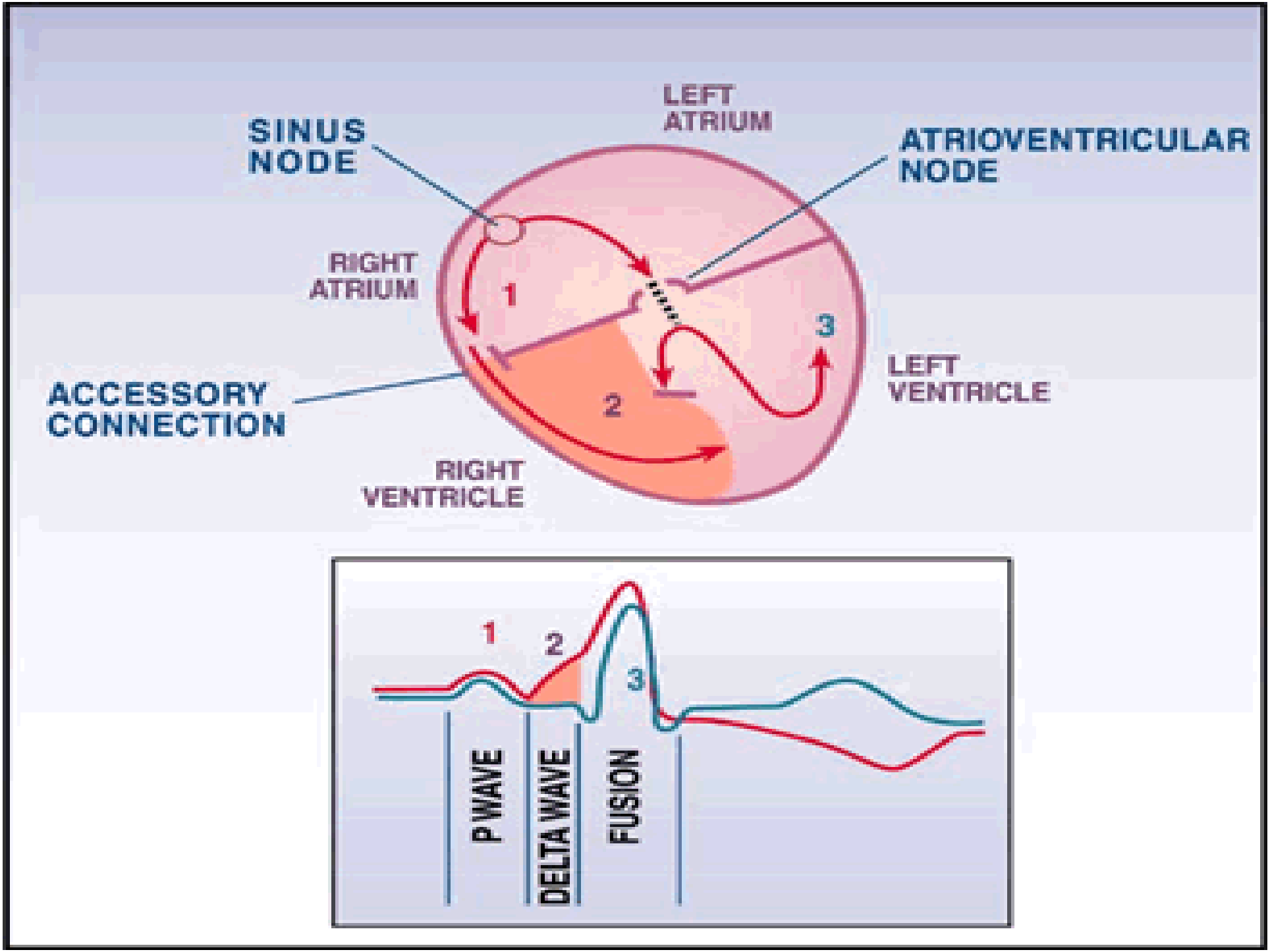
- 0.12-0.20 s (3-5 small squares).
- Best seen in lead II .

PR interval

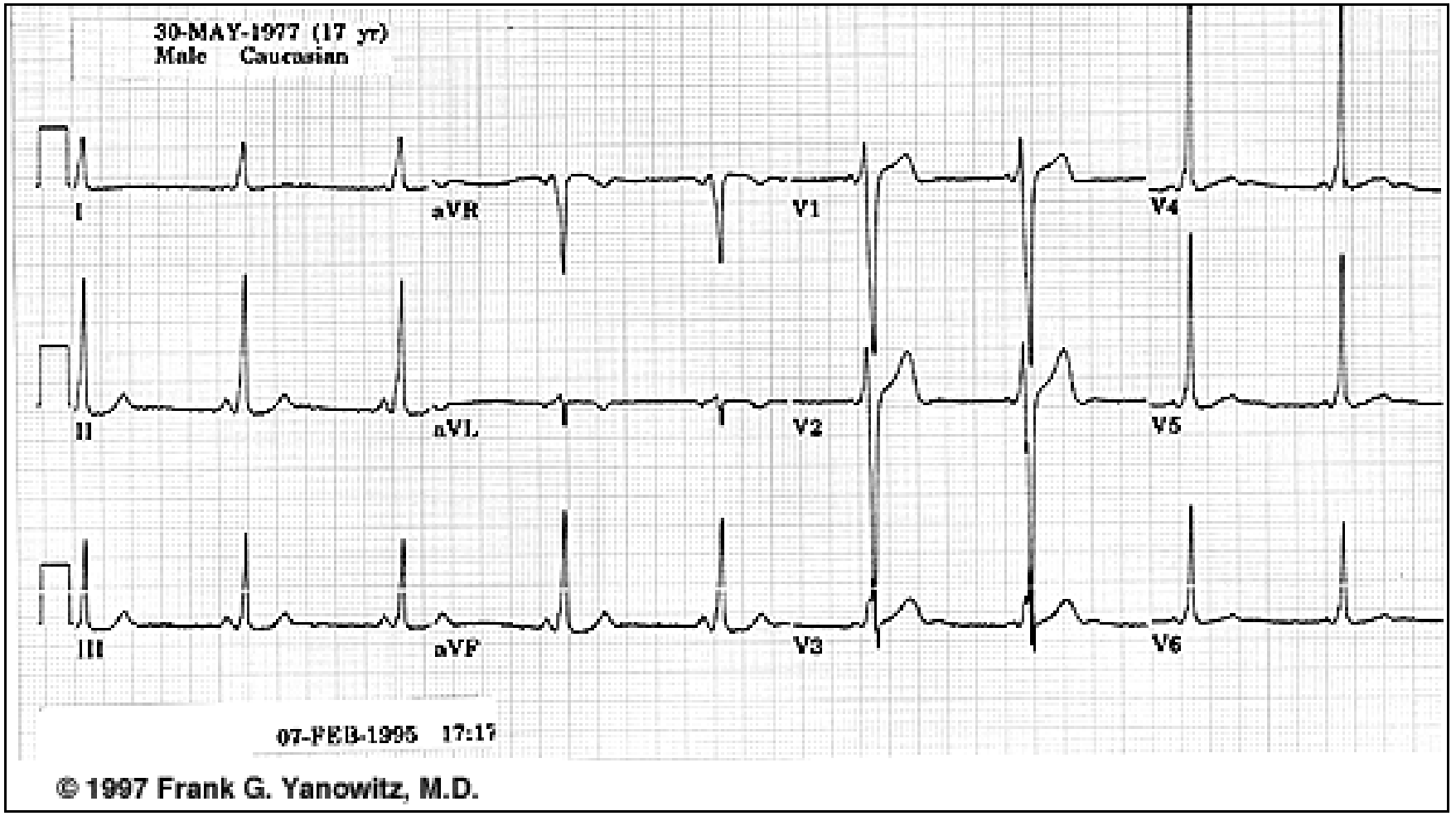
Short PR: < 0.12s

1- Preexcitation syndromes:

*WPW (Wolff-Parkinson-White) Syndrome: An accessory pathway connects the right atrium to the right ventricle or the left atrium to the left ventricle, and this permits early activation of the ventricles (*delta* wave) and a short PR interval.


SINUS NODE
LEFT ATRIUM
ATRIOVENTRICULAR NODE
RIGHT ATRIUM
1
3
LEFT VENTRICLE
ACCESSORY CONNECTION
2
RIGHT VENTRICLE
1
2
3
P WAVE
DELTA WAVE
FUSION

WPW syndrome



PR interval

2- AV Junctional Rhythms with retrograde atrial activation (inverted Ṗ waves in II, III, aVF): Retrograde P waves may occur *before* the QRS complex (usually with a short PR interval), *in* the QRS complex (i.e., hidden from view), or *after* the QRS complex (i.e., in the ST segment).

3- Ectopic atrial rhythms originating near the AV node (the PR interval is short because atrial activation originates close to the AV node; the P wave morphology is different from the sinus P)

4- Normal variant

5- tachycardia

PR interval

Prolonged PR: >0.20s

1-First degree AV block (PR interval usually constant)

2-Second degree AV block (PR interval may be normal or prolonged; some P waves do not conduct)

Type I (Wenckebach): Increasing PR until nonconducted P wave occurs

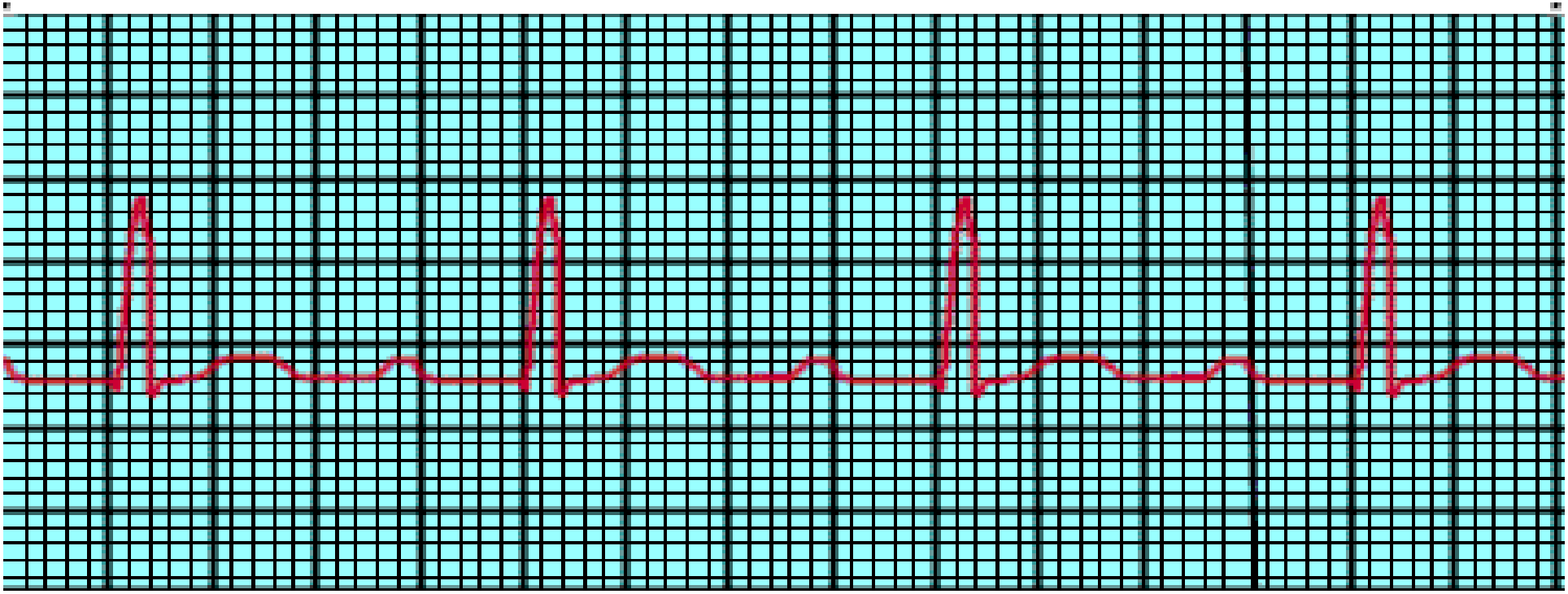
Type II (Mobitz): Fixed PR intervals plus nonconducted P waves

3-AV dissociation: Some PR's may appear prolonged, but the P waves and QRS complexes are dissociated .

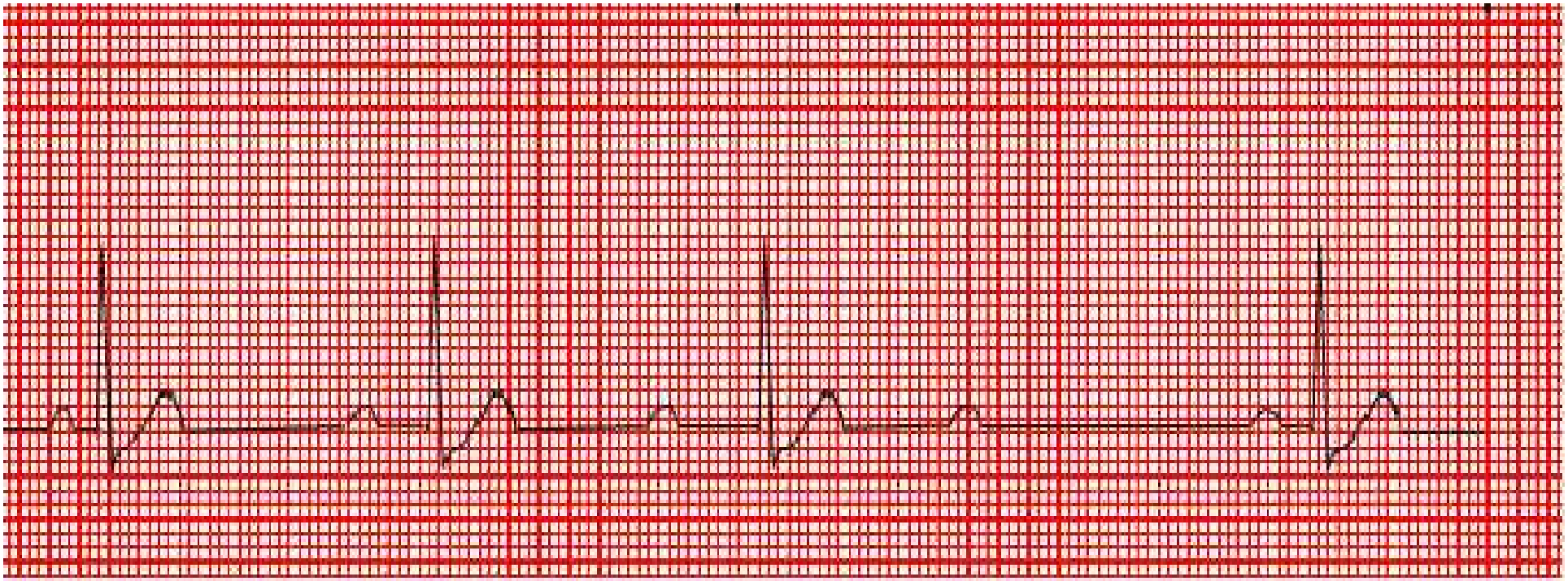
4- Rheumatic fever

5- Digitalis

First degree AV block

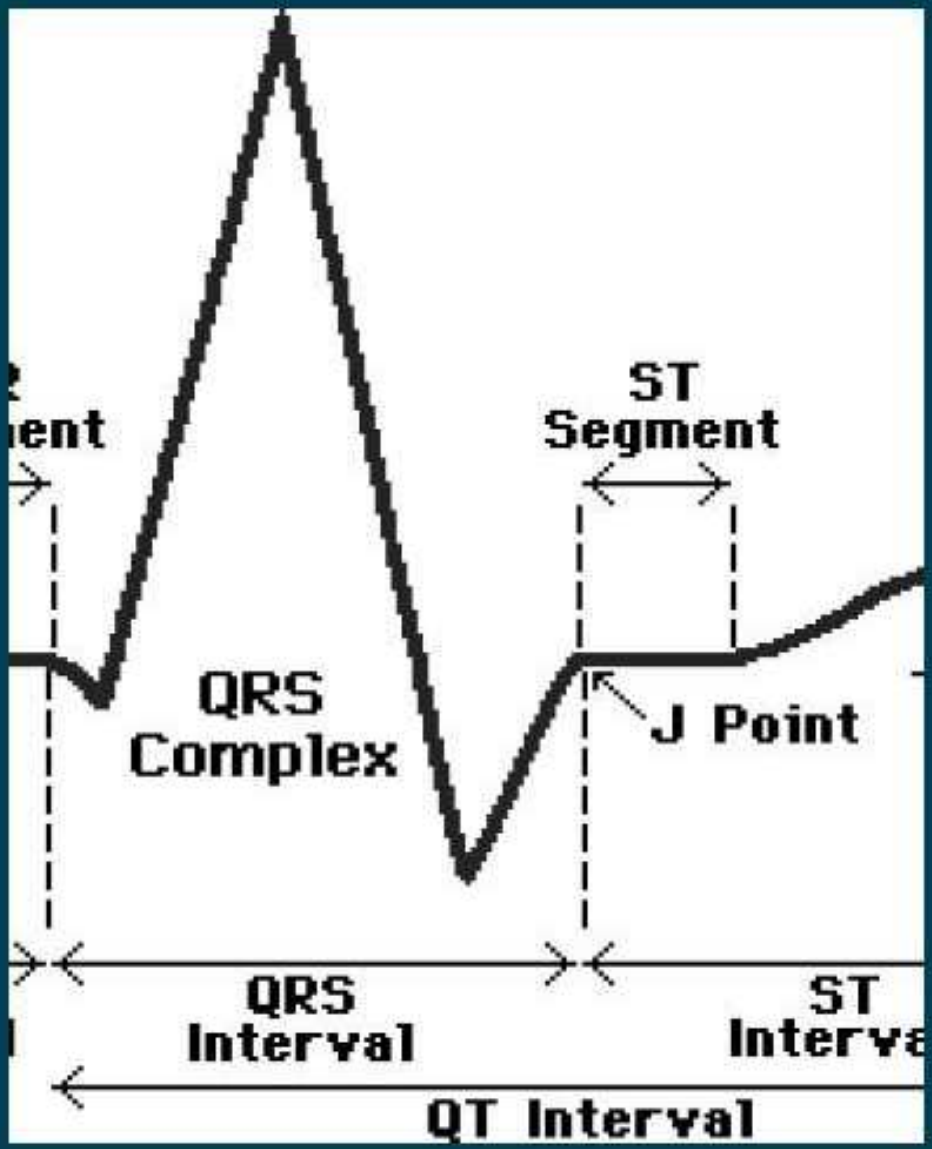


Second degree AV block (mobitz I)-Wenckebach



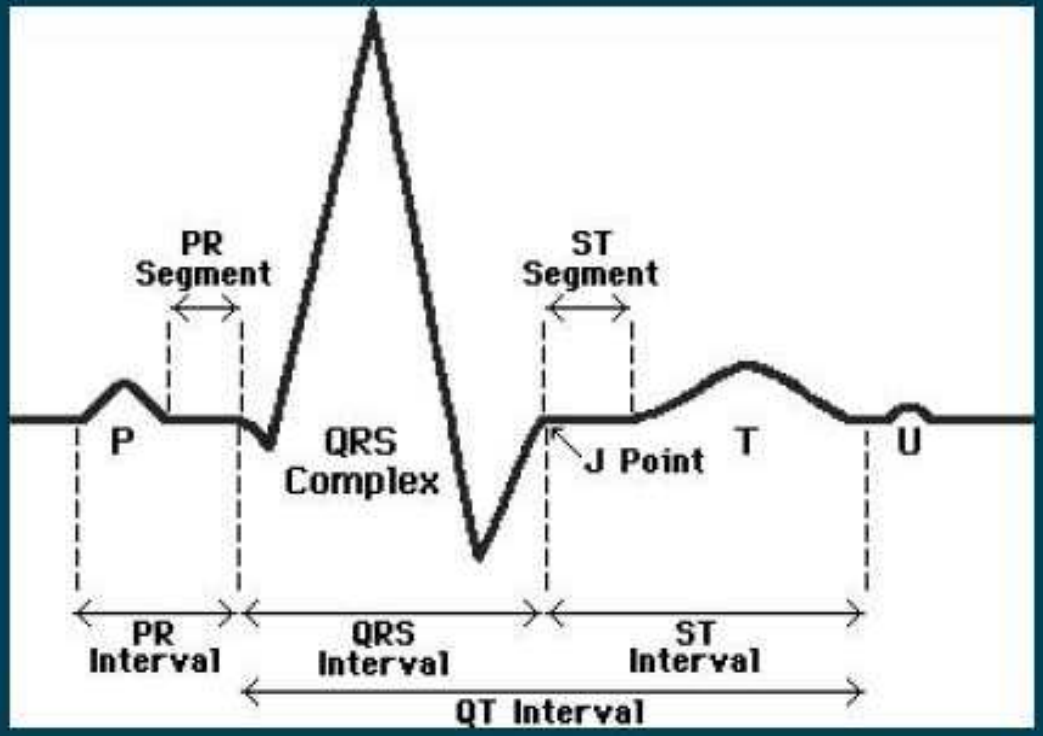
QRS complex

Definitions



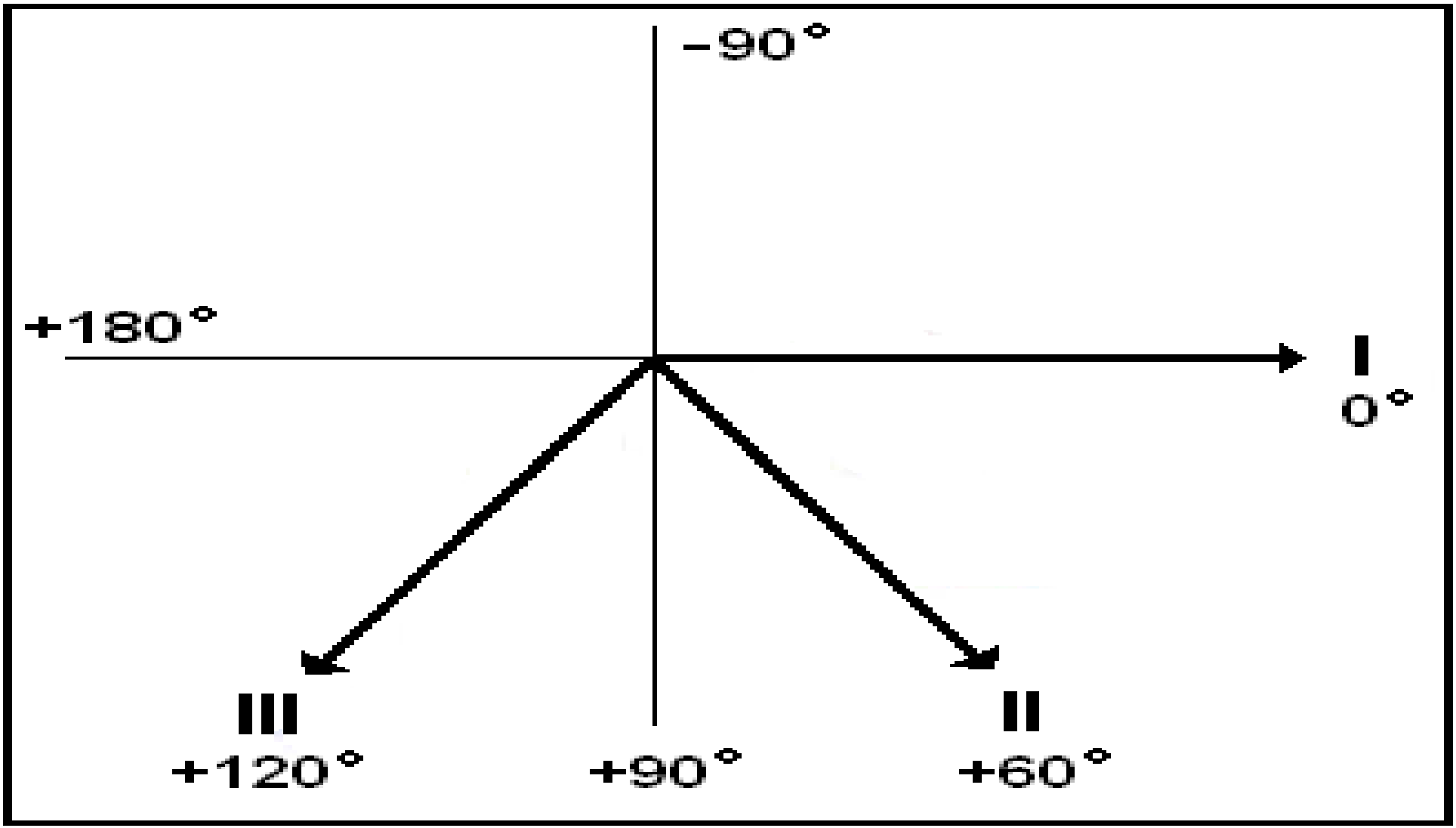
- The Q wave is the first portion of the ventricular depolarization if it is negative
- The first upward deflection is the R wave
- A negative deflection after an R wave is an S wave
- If the whole thing is negative it's a QS complex
- If there's no Q wave its an RS
- A second R wave after the S is an R' (or r') (r prime)

The QRS Complex

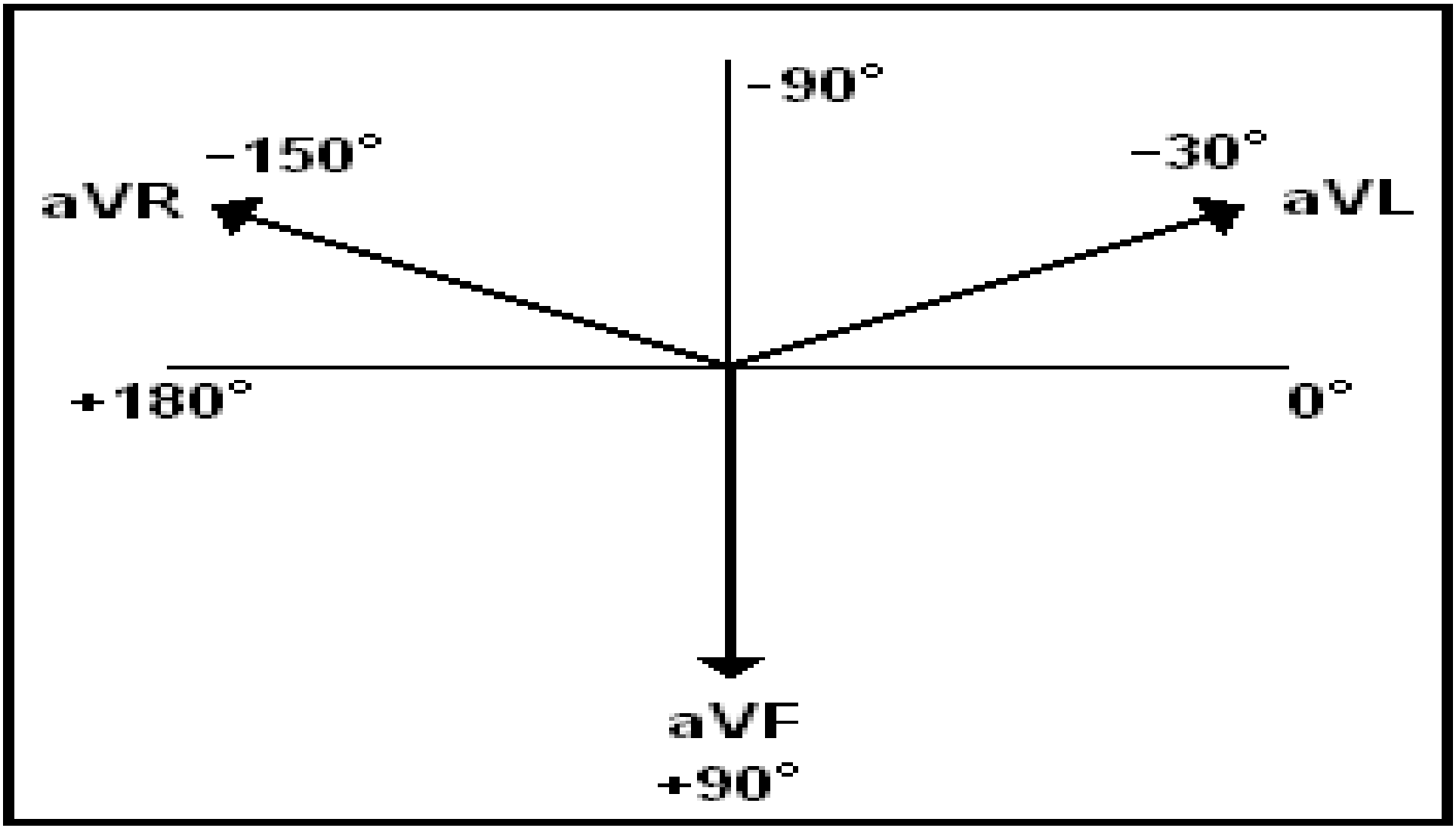


- Axis
- Duration (width)
- Initial deflection
- Voltage
- Morphology

Standard Limb Leads



Augmented Limb Leads



The QRS Axis

The QRS axis represents the net overall direction of the heart's electrical activity.

Abnormalities of axis can hint at:

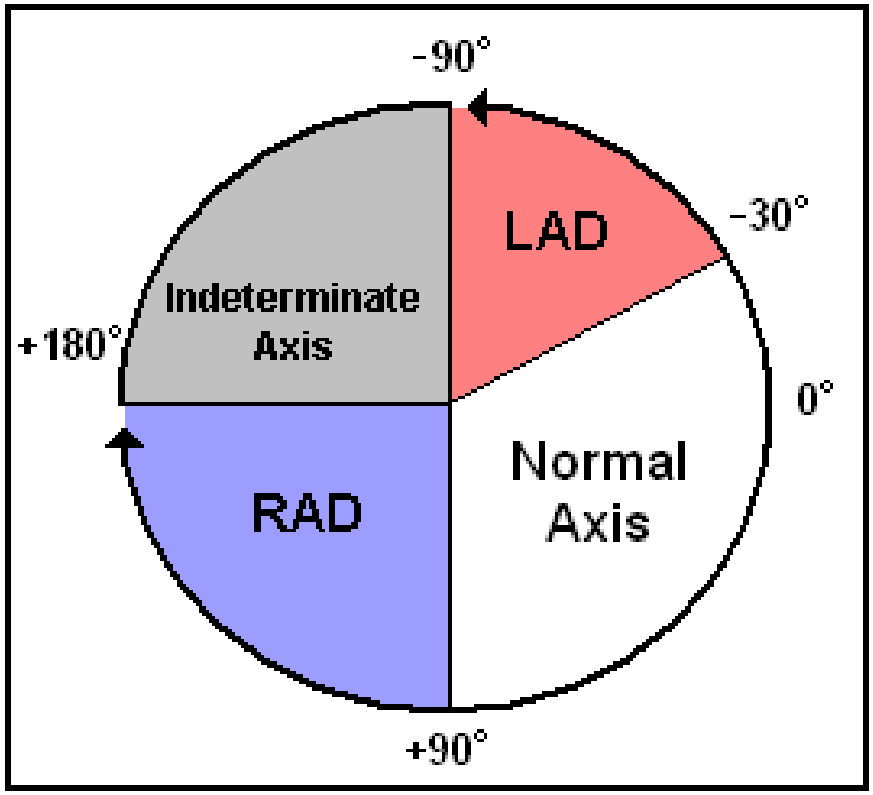
- Ventricular enlargement
- Conduction blocks (i.e. hemiblocks)

The QRS Axis

By near-consensus, the normal QRS axis is defined as ranging from -30° to +90° .

-30° to -90° is referred to as a left axis deviation (LAD)

+90° to +180° is referred to as a right axis deviation (RAD)



Determining the Axis

- The Quadrant Approach
- The Equiphasic Approach

Determining the Axis



Predominantly Positive



Predominantly Negative



Equiphasic

The Quadrant Approach

1. Examine the QRS complex in leads I and aVF to determine if they are predominantly positive or predominantly negative. The combination should place the axis into one of the 4 quadrants below.

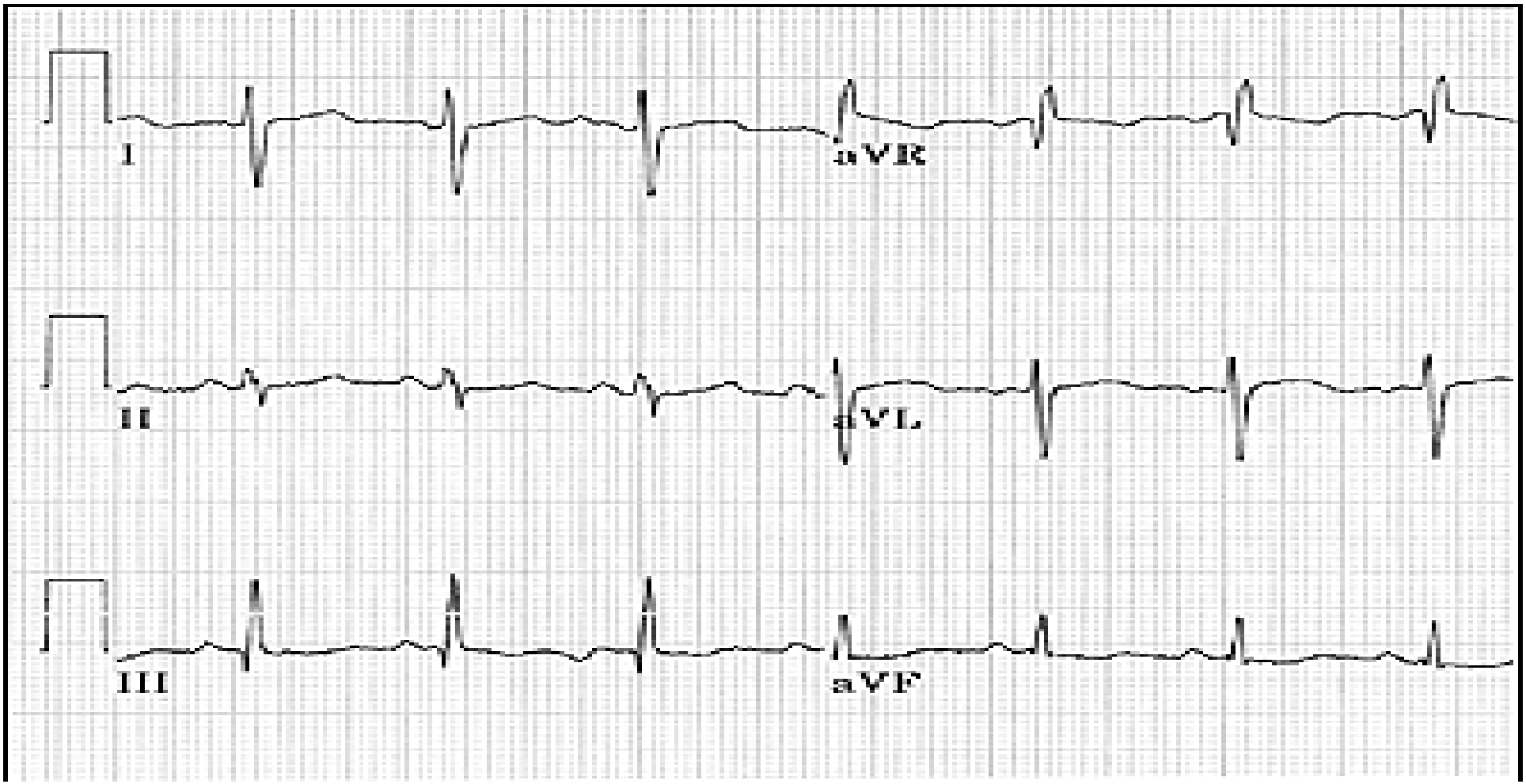
		Lead aVF: Positive	Lead aVF: Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

The Quadrant Approach

2. In the event that LAD is present, examine lead II to determine if this deviation is pathologic. If the QRS in II is predominantly positive, the LAD is non-pathologic (in other words, the axis is normal). If it is predominantly negative, it is pathologic.

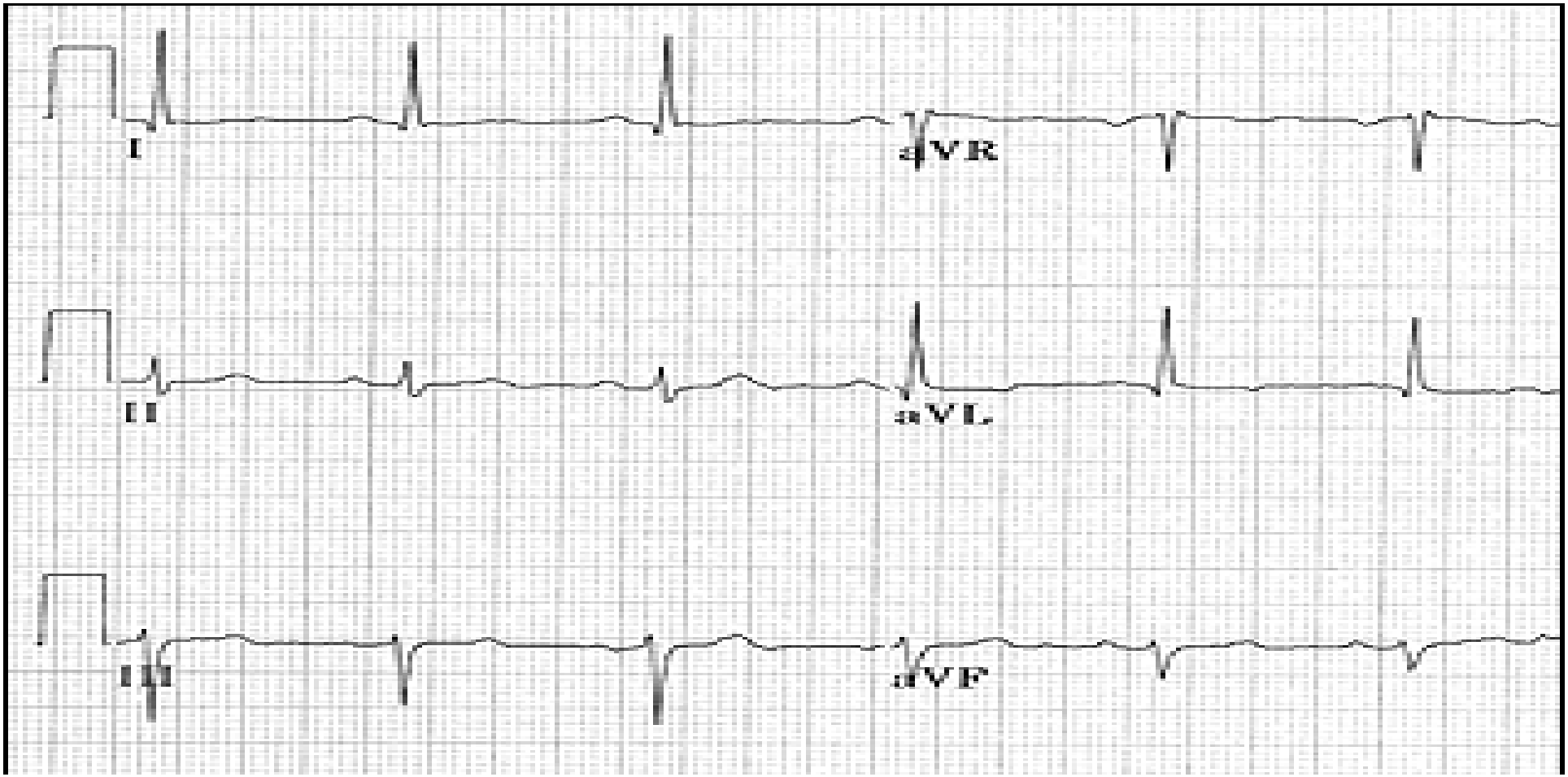
		Lead aVF	
		Positive	Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

Quadrant Approach: Example 1



Negative in I, positive in aVF RAD

Quadrant Approach: Example 2



**Positive in I, negative in aVF Predominantly positive in II **

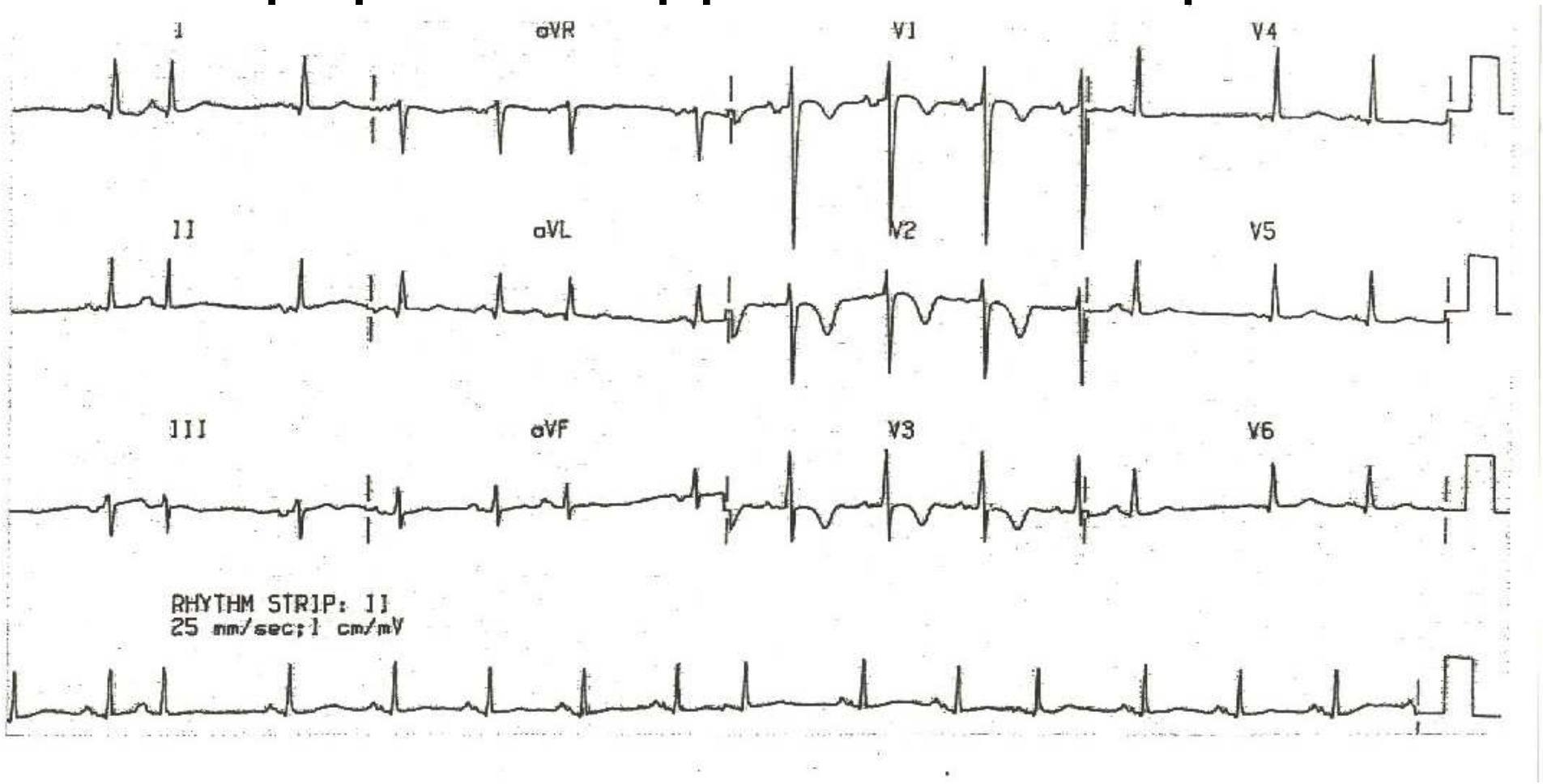
Normal Axis (non-pathologic LAD)

The Equiphasic Approach

1. Determine which lead contains the most equiphasic QRS complex. The fact that the QRS complex in this lead is equally positive and negative indicates that the net electrical vector (i.e. overall QRS axis) is perpendicular to the axis of this particular lead.

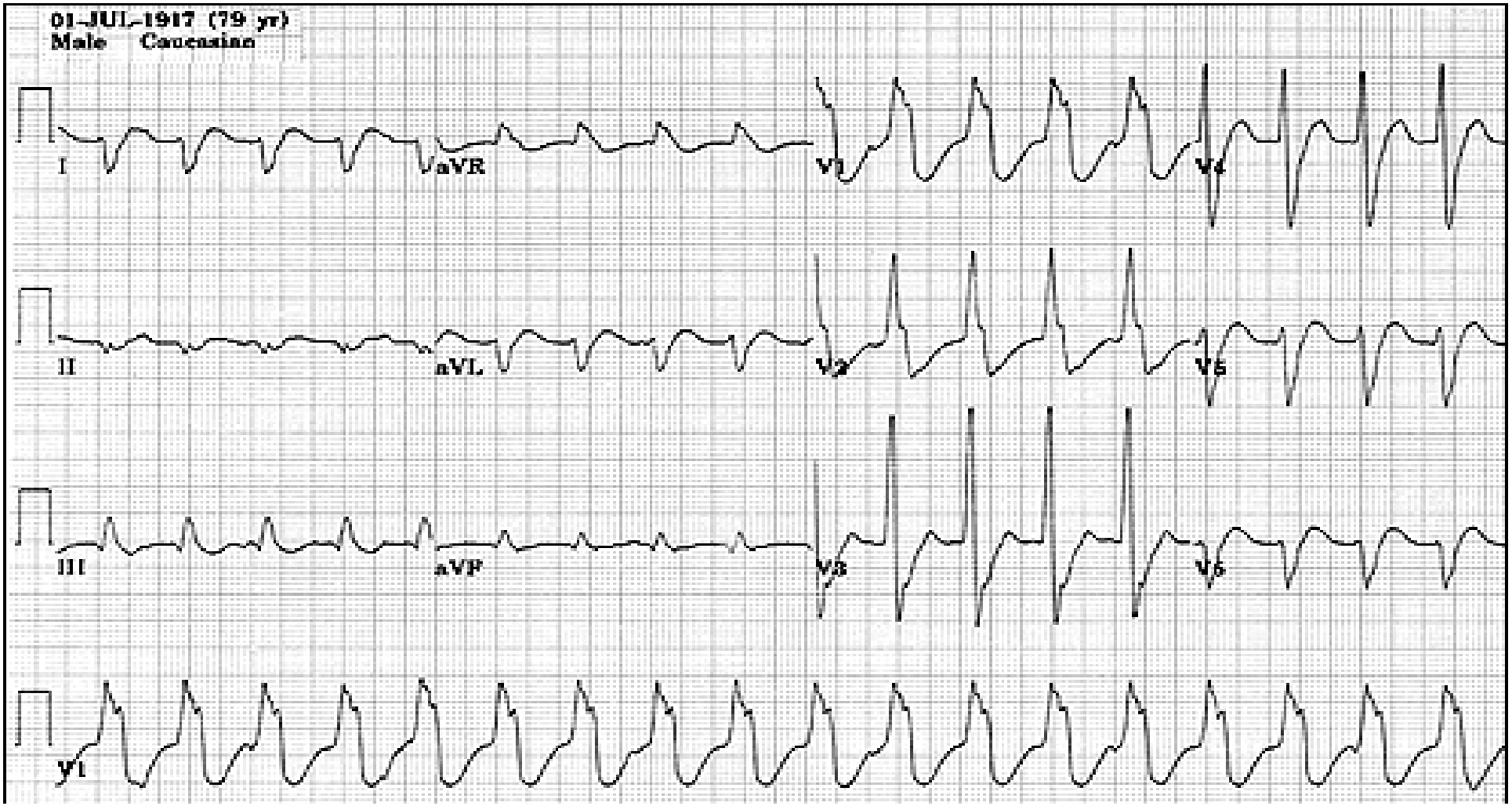
2. Examine the QRS complex in whichever lead lies 90° away from the lead identified in step 1. If the QRS complex in this second lead is predominantly positive, than the axis of this lead is approximately the same as the net QRS axis. If the QRS complex is predominantly negative, than the net QRS axis lies 180° from the axis of this lead.

Equiphasic Approach: Example 1



Equiphasic in aVF Predominantly positive in I QRS axis ≈ 0°

Equiphasic Approach: Example 2



Equiphasic in II → Predominantly negative in aVL → QRS axis ≈ +150°

QRS complex

- Normal: 0.06 - 0.10s

Prolonged QRS Duration (>0.10s):

A-QRS duration 0.10 - 0.12s

1- Incomplete right or left bundle branch block

2-Nonspecific intraventricular conduction delay (IVCD)

3-Some cases of left anterior or posterior fascicular block

B-QRS duration ≥ 0.12s

1-Complete RBBB or LBBB

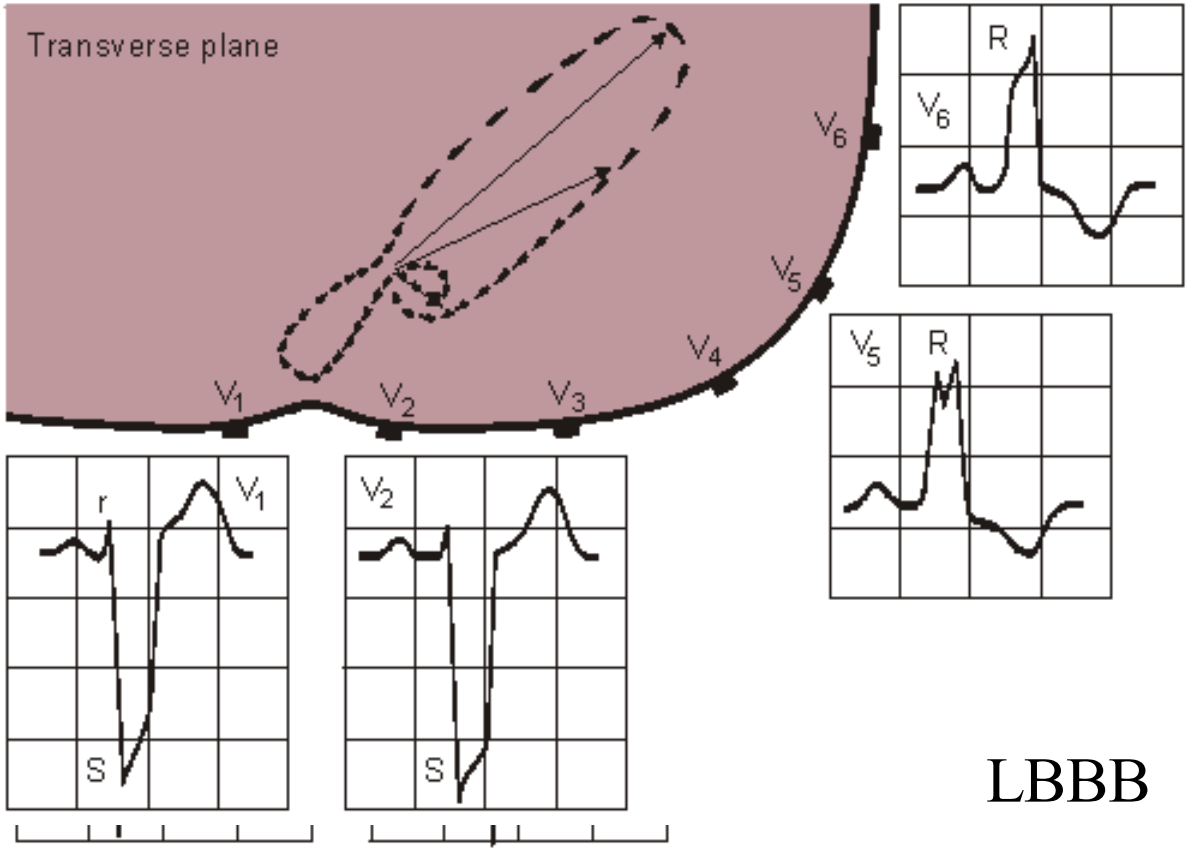
2-Nonspecific IVCD

3-Ectopic rhythms originating in the ventricles (e.g., ventricular tachycardia, pacemaker rhythm)

Left Bundle Branch Block Criteria

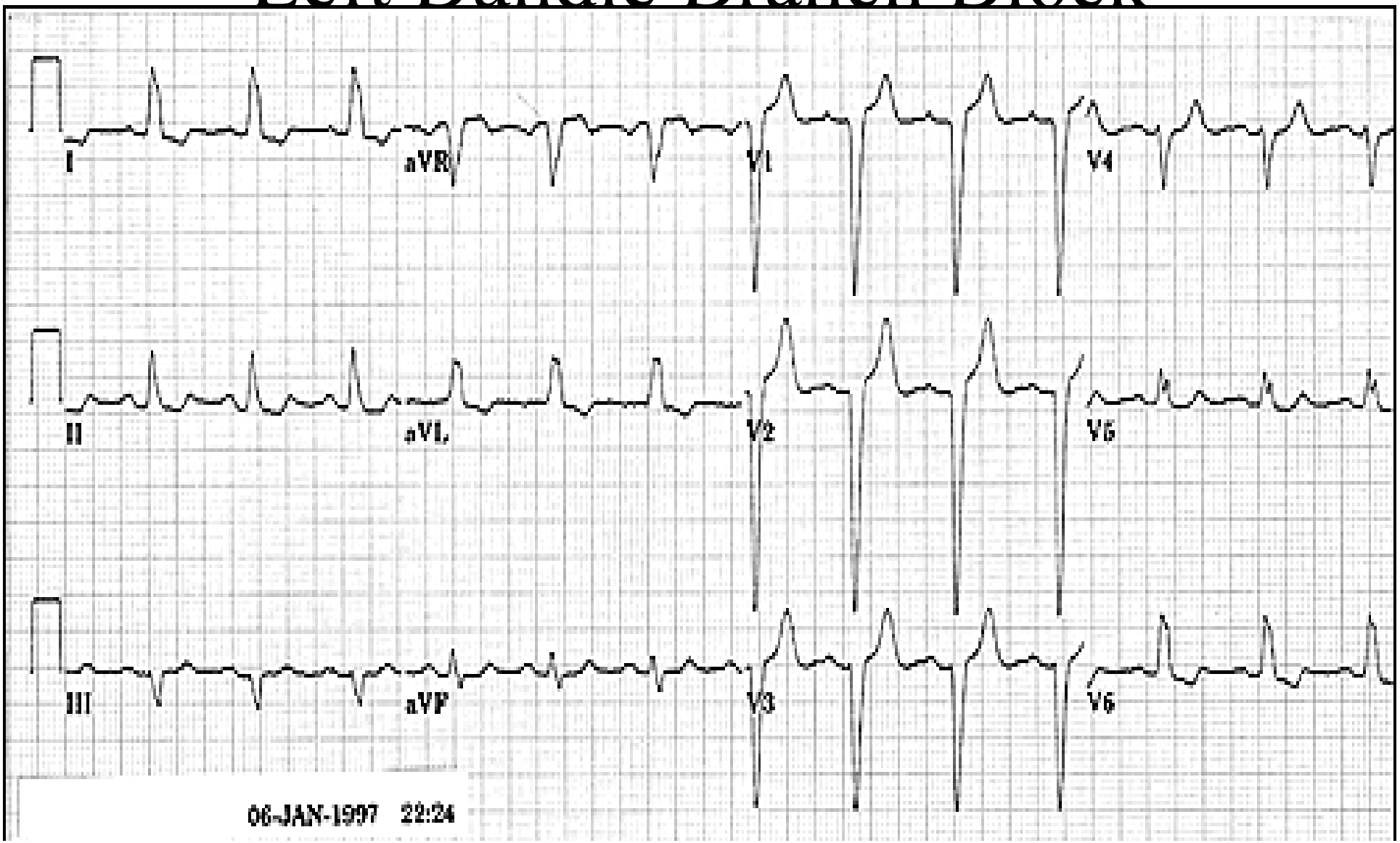
- QRS duration $\geq$ 120ms
- Broad R wave in I and V_6
- Prominent QS wave in V_1
- Absence of q waves (including physiologic q waves) in I and V_6



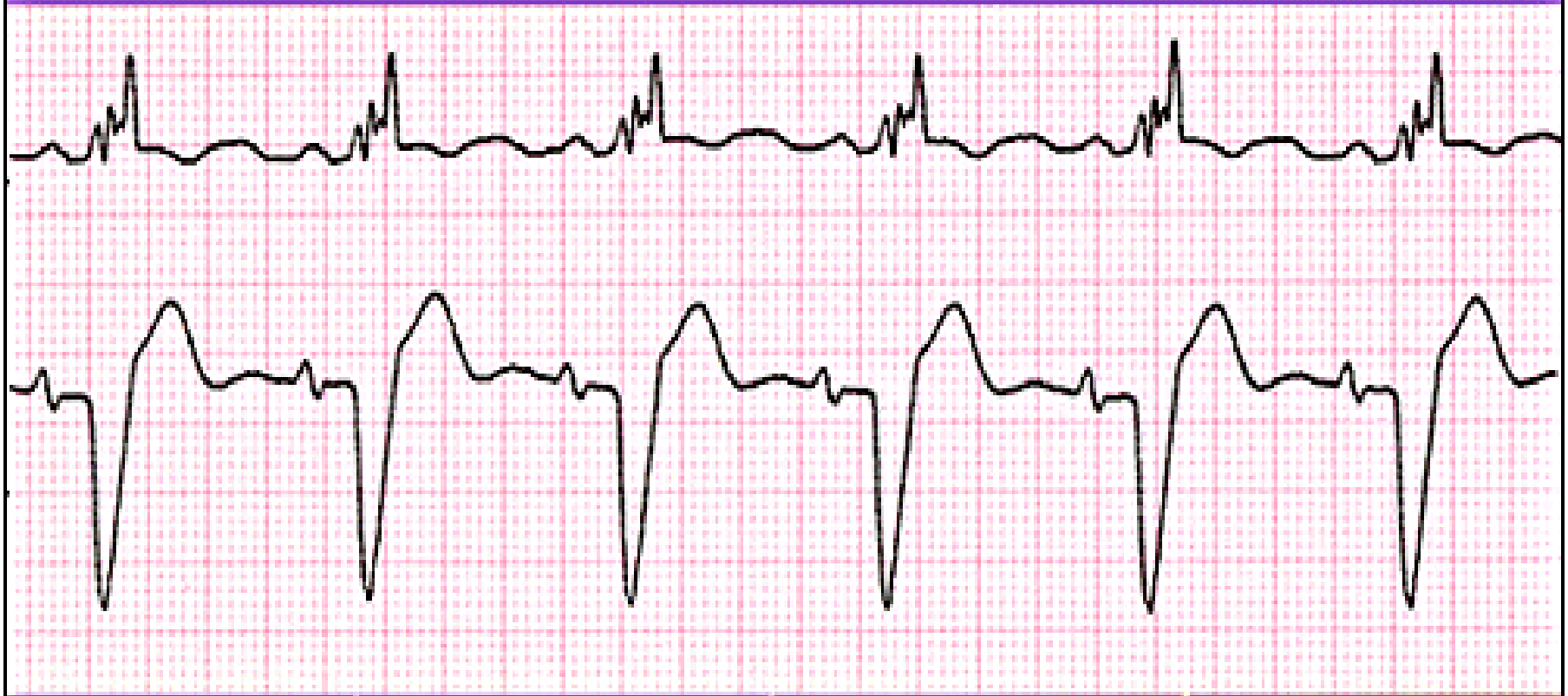


LBBB

Left Bundle Branch Block



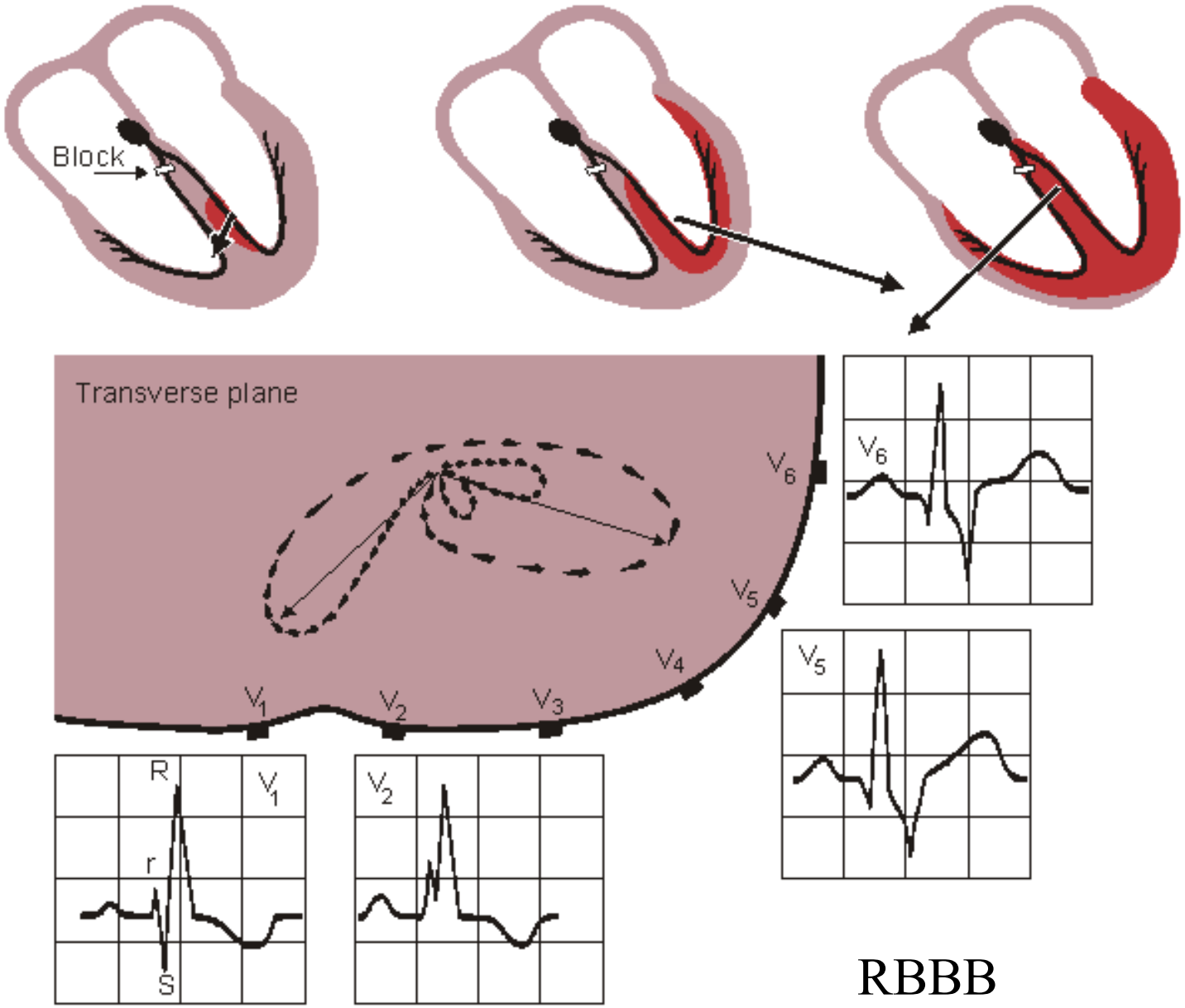
Left Bundle Branch Block



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	.12 to .20	≥.12	RR' in V5

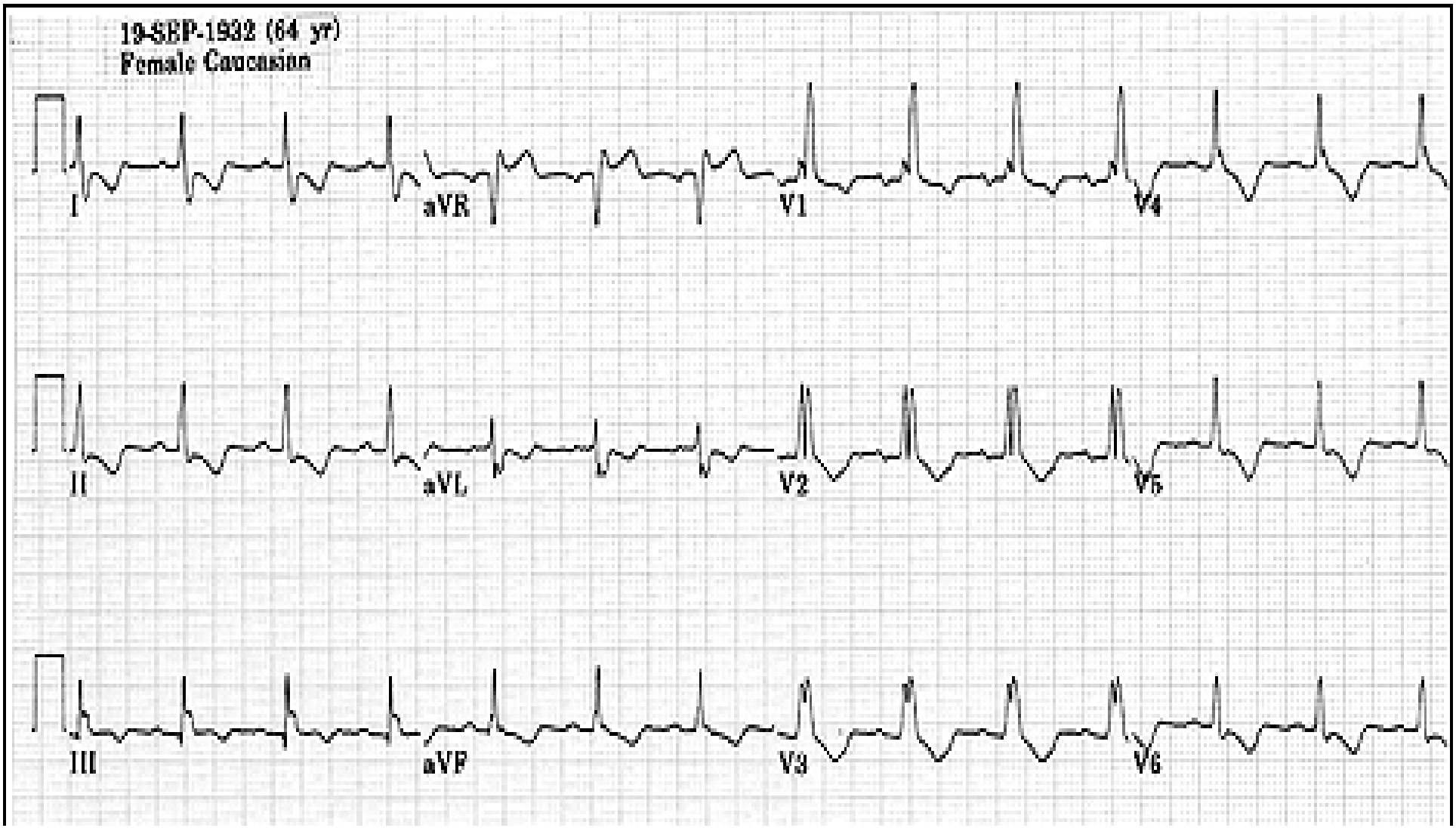
Right Bundle Branch Block Criteria

- QRS duration $\geq$ 110ms
- rSR' pattern or notched R wave in V_1
- Wide S wave in I and V_6

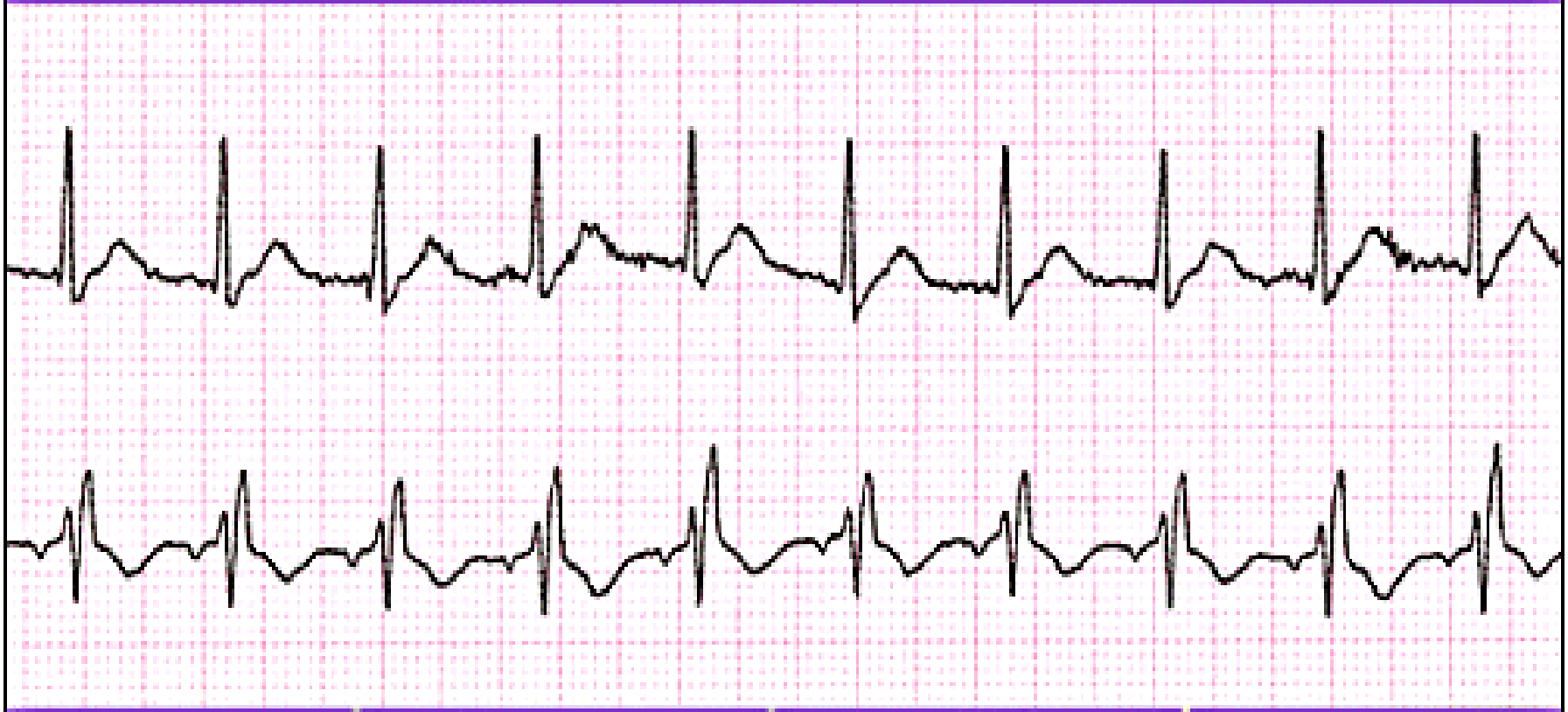


RBBB

Right Bundle Branch Block



Right Bundle Branch Block



P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	.12 to .20	>.12	RSR' in V1

Wide QRS Beats



Wide QRS with a p wave Bundle Branch Block



Wide QRS with no p wave Ventricular beat

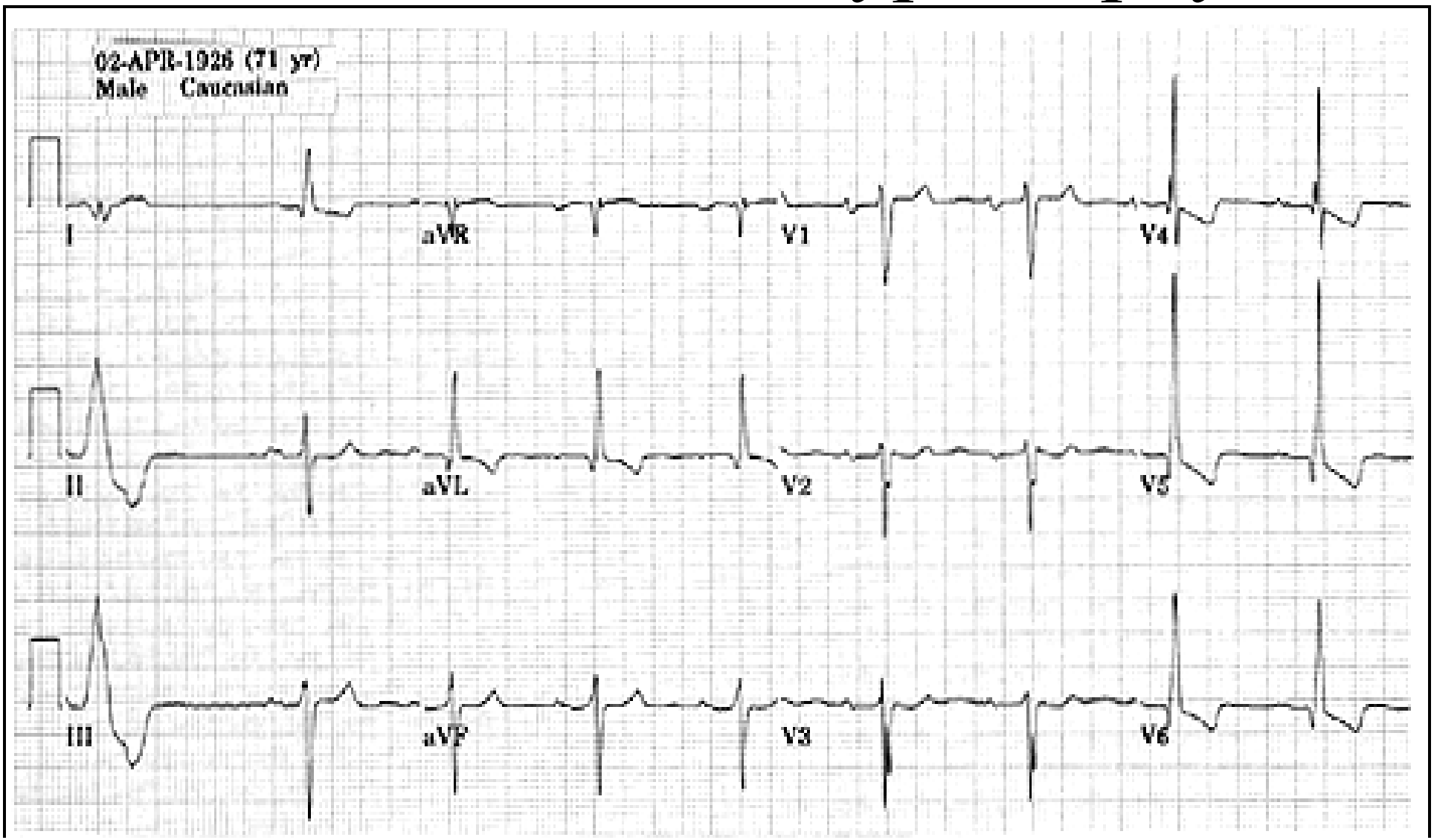
Left Ventricular Hypertrophy

- R in I + S in III > 25mm
- S in V_1 + R in V_5 (or $_6$) >35 mm
- R in aVL >11mm

} voltage criteria

- Lateral ST/T changes
- Left atrial enlargement is supporting evidence

Left Ventricular Hypertrophy

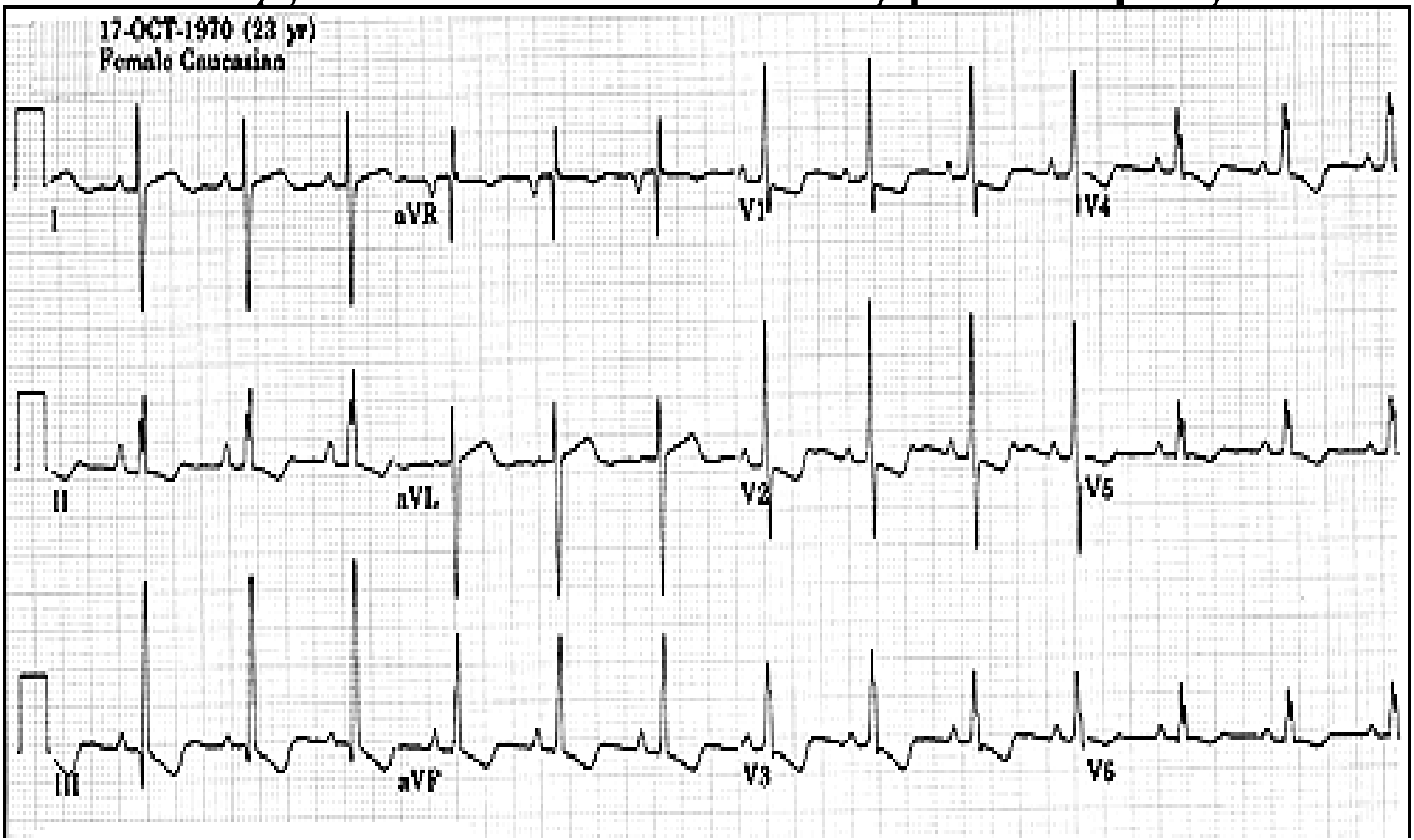


Right Ventricular Hypertrophy

Although there is no widely accepted criteria for detecting the presence of RVH, any combination of the following ECG features is suggestive of its presence:

- Right axis deviation
- Right atrial enlargement
- Down sloping ST depressions in V_1-V_3 (RV strain pattern)
- Tall R wave in V_1

Right Ventricular Hypertrophy



Q Wave

- Normal (physiologic) or due to pathology (pathologic).
- Depth and width are determining criteria
  - Q wave >0.04 (40 ms) wide is considered a significant finding (pathologic)

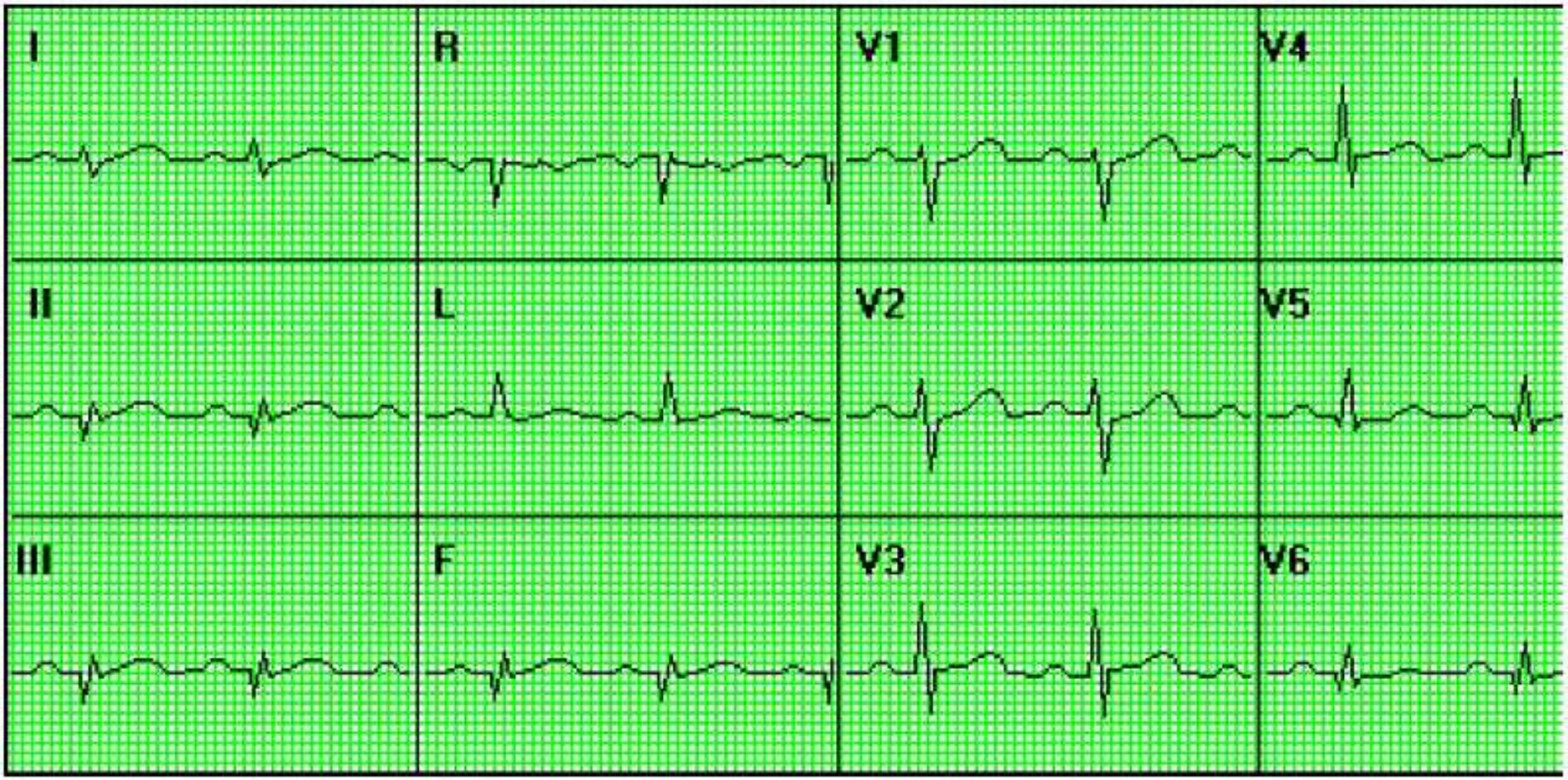
Initial deflection: Is there a Q wave?

- The earliest part of the left ventricle to depolarize is the septum which depolarizes from left to right.
- This will lead to a small upright deflection in V_1-V_2 and a small negative deflection in the left leads I, aVL, and (V_4-V_6) as well as sometimes in the inferior leads.
- These normal Q waves are narrow (< 0.04 seconds) and usually not deep and are known as septal Q's.

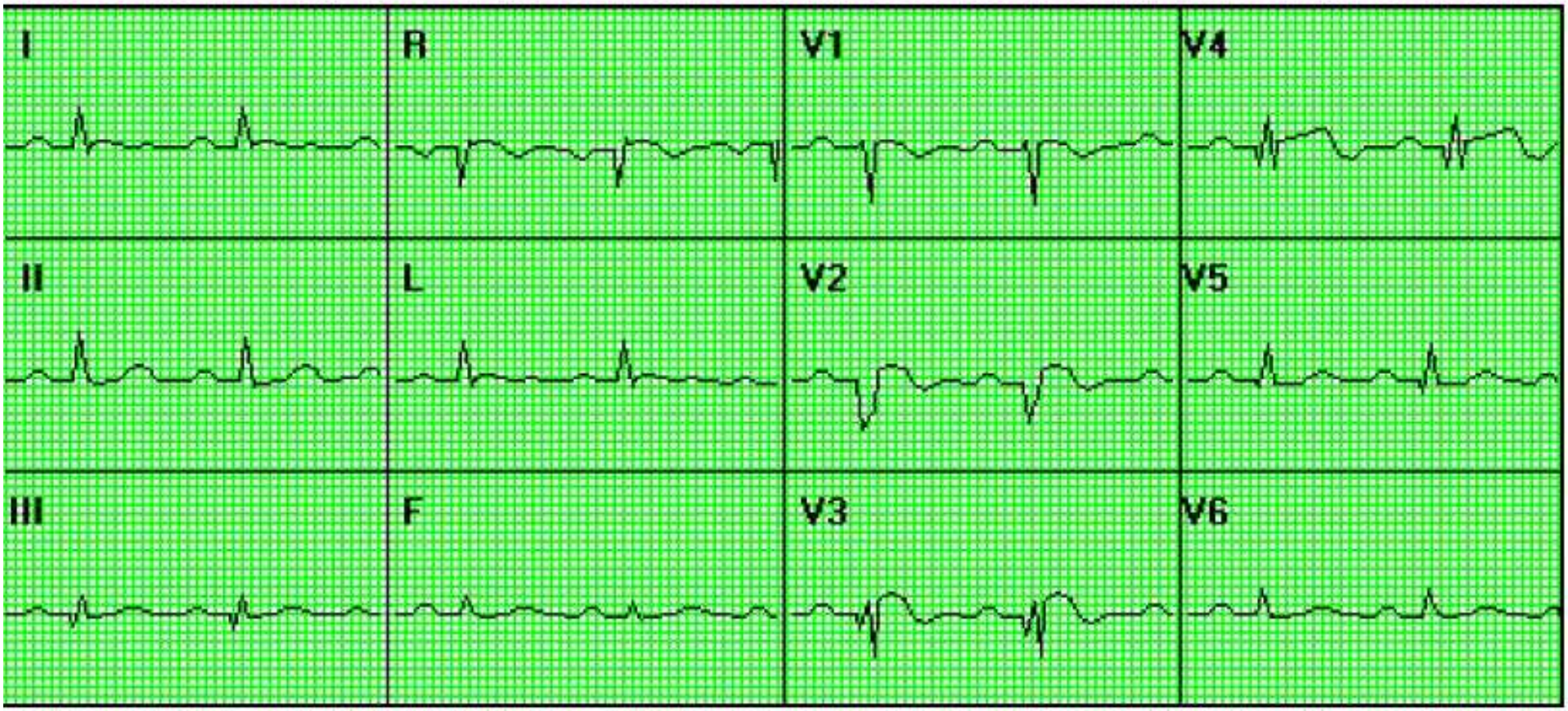
Q waves of Myocardial Infarction

- "Pathologic" Q waves are considered the hallmark of myocardial infarction
- Q must be >.04 seconds in width and/or more than 25% of the height of the R wave in the same lead
- aVR doesn't count
- Q in III alone doesn't count

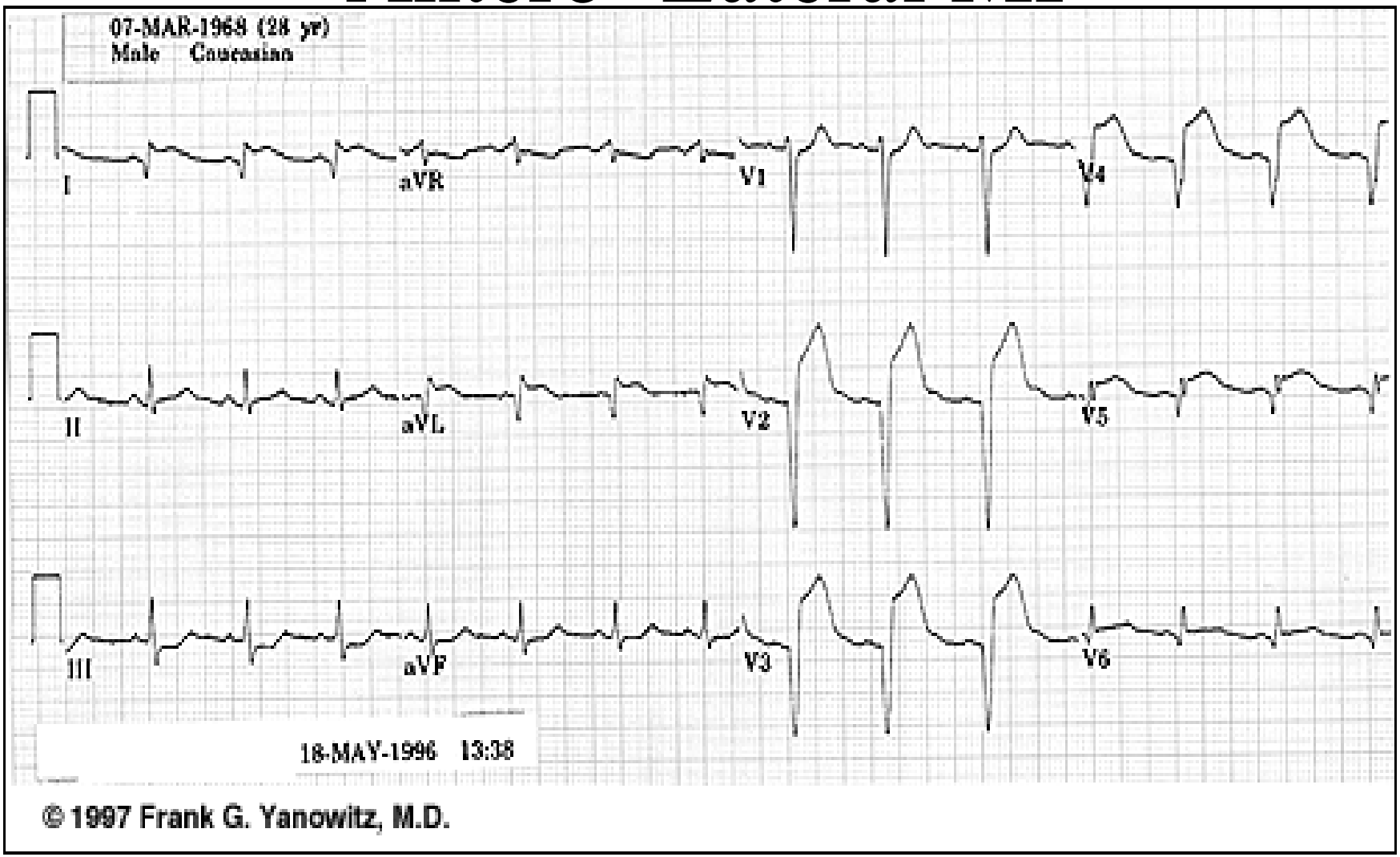
Q Waves of Inferior MI



Q Waves of Anterior MI



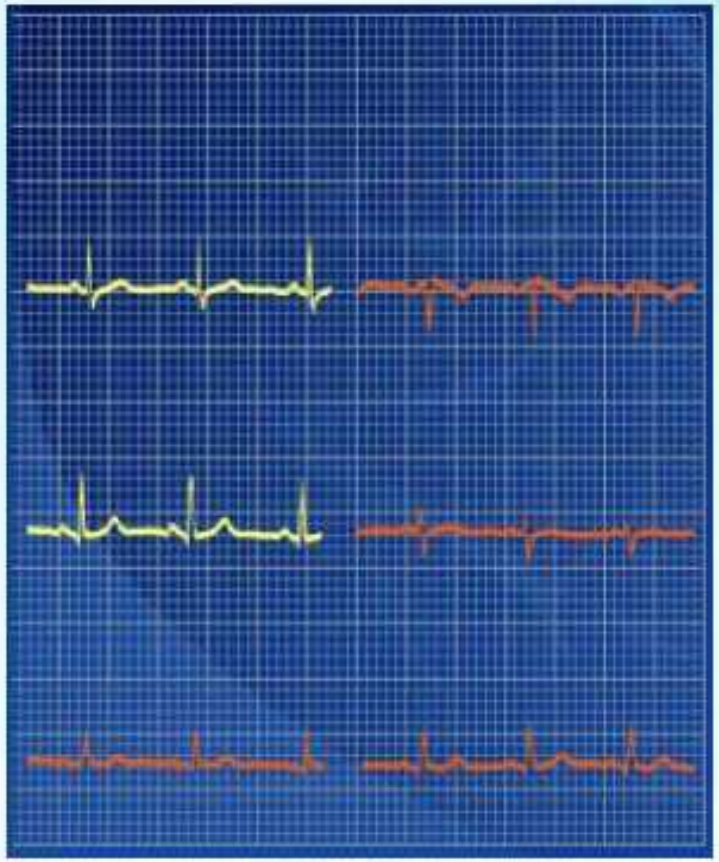
Antero -Lateral MI



NHS

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Rule 3

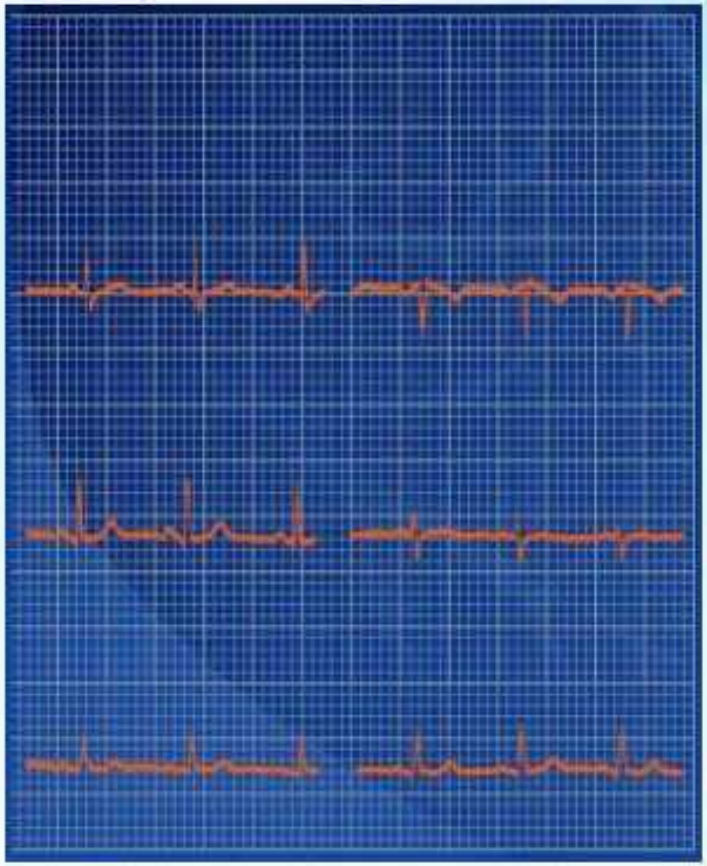


The QRS complex should be dominantly upright in leads I and II

NHS

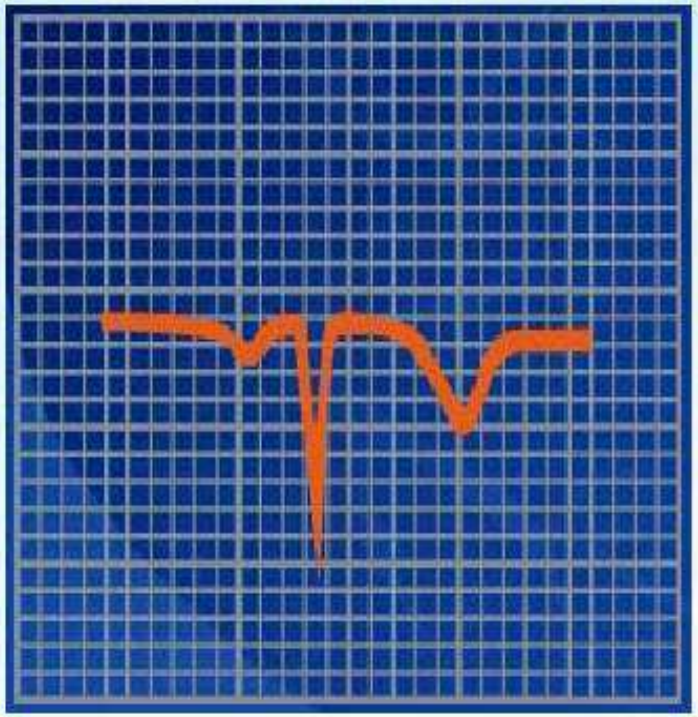
Essex Cardiac Network

Rule 4



QRS and T waves tend to have the same general direction in the limb leads

Rule 5

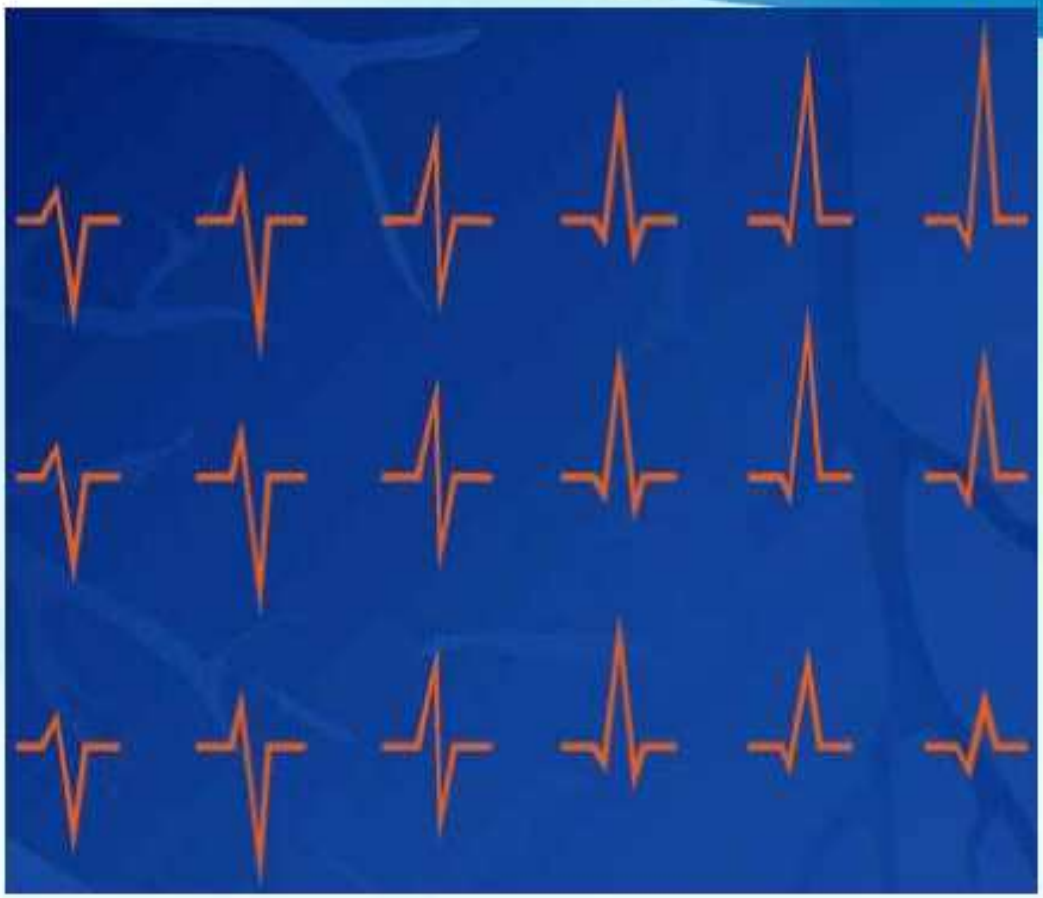


All waves are negative in lead aVR

NHS

Essex Cardiac Network

Rule 6



The R wave in the precordial leads must grow from V1 to at least V4

Rule 9

NHS

Essex Cardiac Network



There should be no Q wave or only a small q less than 0.04 seconds in width in I, II, V2 to V6

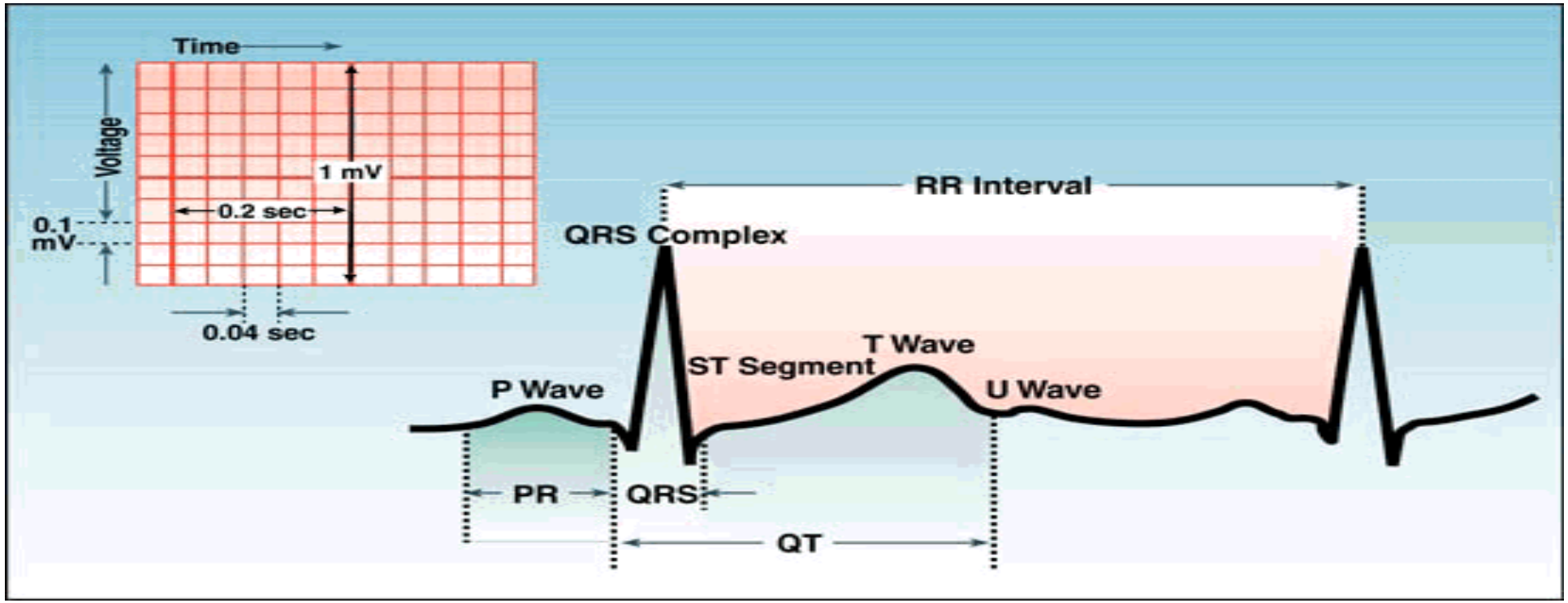
The

ST segment

ST segment

From the end of QRS (J point) to beginning of T wave .

isoelectric



ST Segment

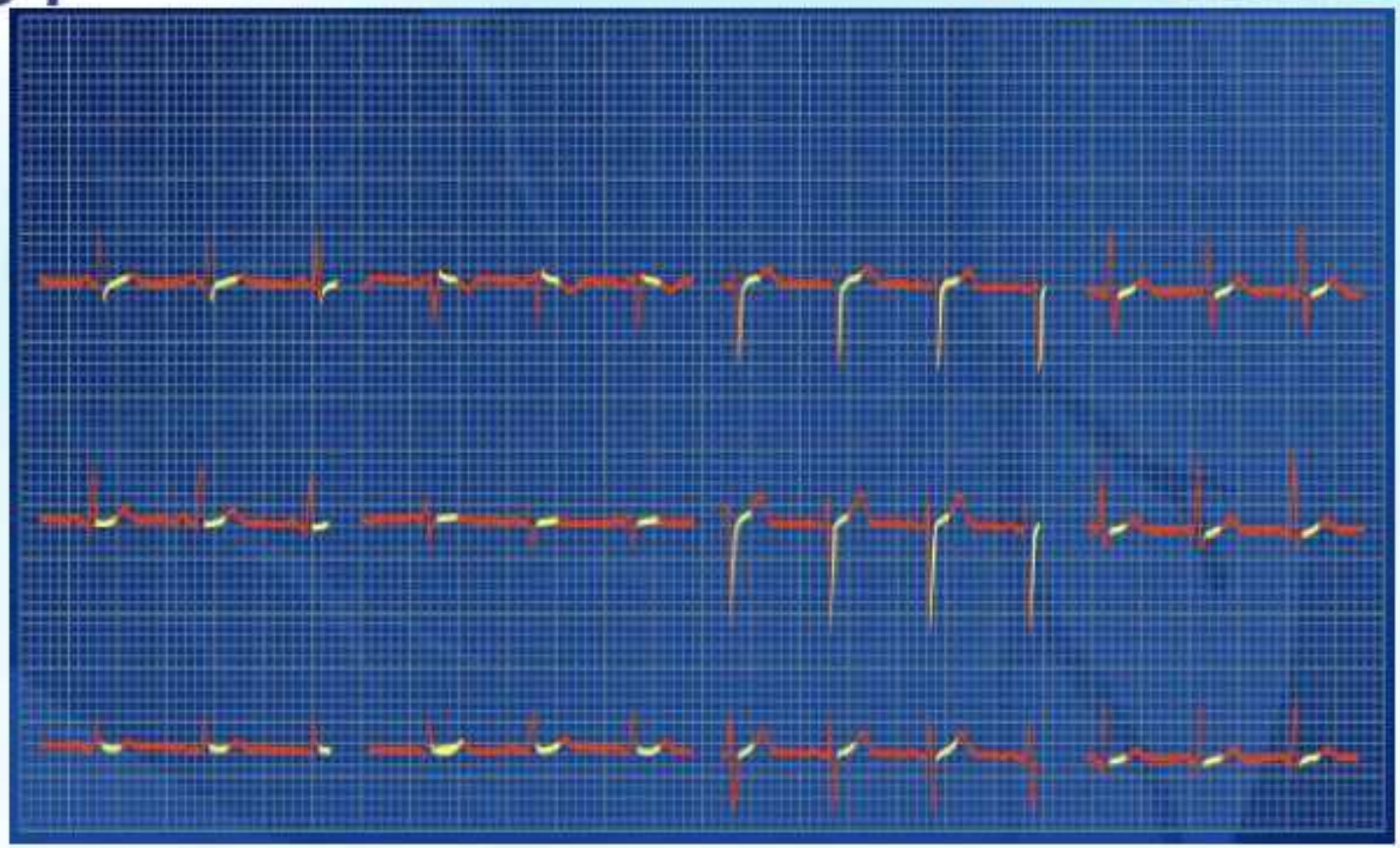
- The ST segment is normally level with the T-P segment rather than the PR segment

- Examine every lead for ST segment elevation of 1 mm or more.

NHS

Essex Cardiac Network

Rule 7



The ST segment should start isoelectric except in V1 and V2 where it may be elevated

Differential Diagnosis of ST Segment Elevation

1-Normal Variant "Early Repolarization" (usually concave upwards, ending with symmetrical, large, upright T waves)

2- Ischemic Heart Disease (usually convex upwards, or straightened) Acute transmural injury - as in this acute anterior MI

3- Persistent ST elevation after acute MI suggests ventricular aneurysm

4-ST elevation may also be seen as a manifestation of Prinzmetal's (variant) angina (coronary artery spasm)

5-ST elevation during exercise testing suggests extremely tight coronary artery stenosis or spasm (transmural ischemia)

•

Differential Diagnosis of ST Segment Elevation

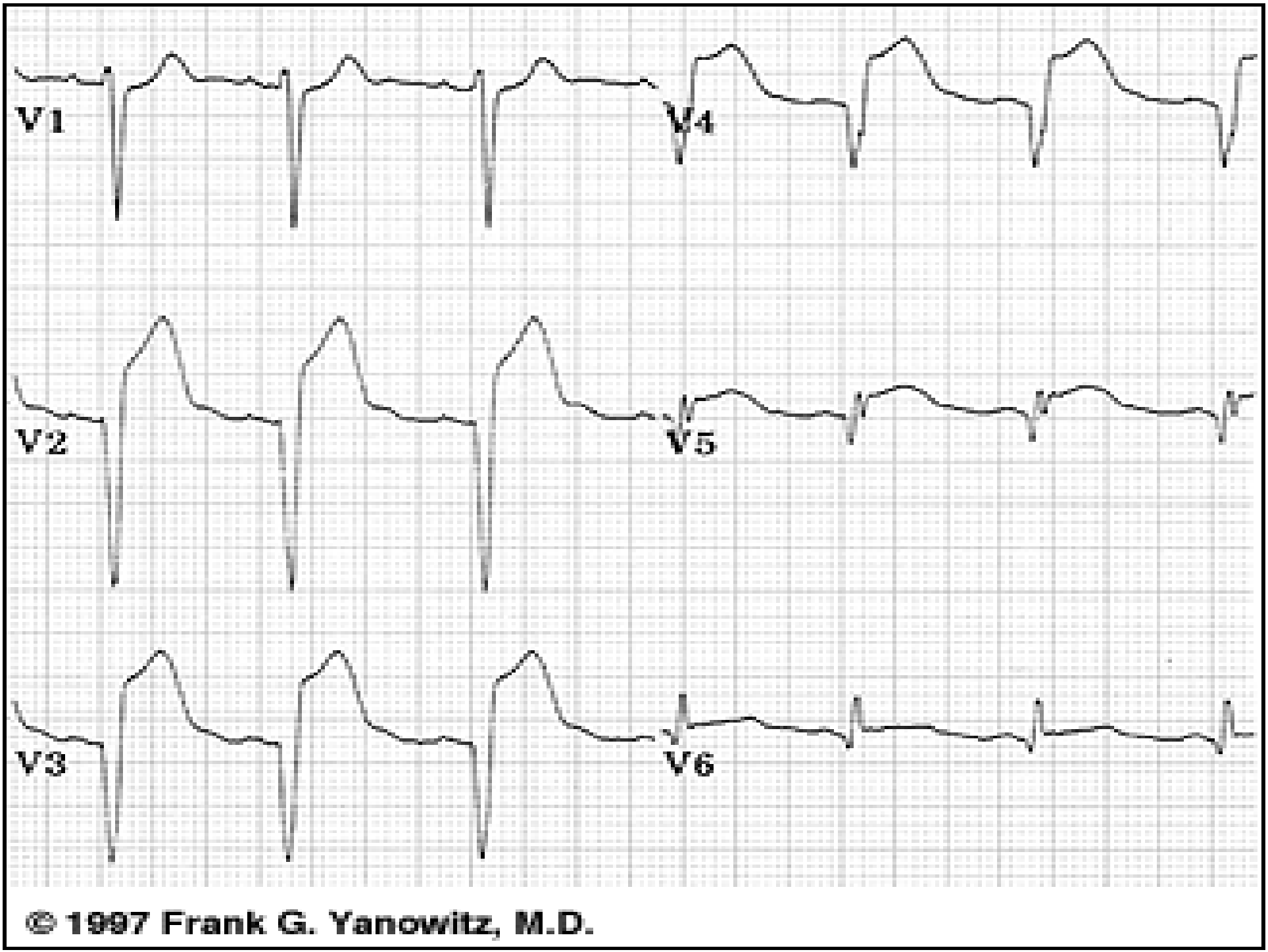
6-Acute Pericarditis

#Concave upwards ST elevation in most leads except aVR

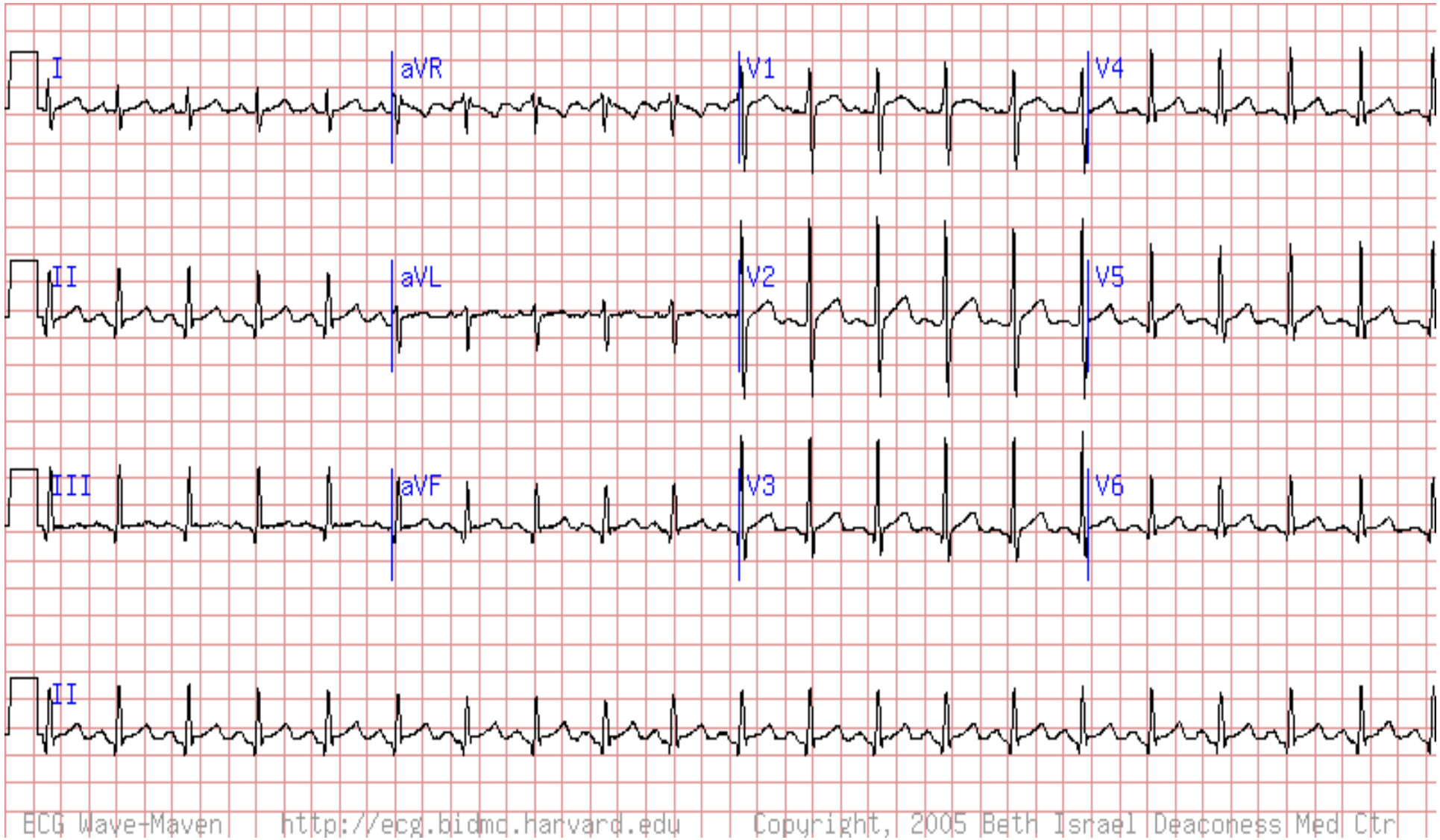
No reciprocal ST segment depression (except in aVR)

#Unlike "early repolarization", T waves are usually low amplitude, and heart rate is usually increased.

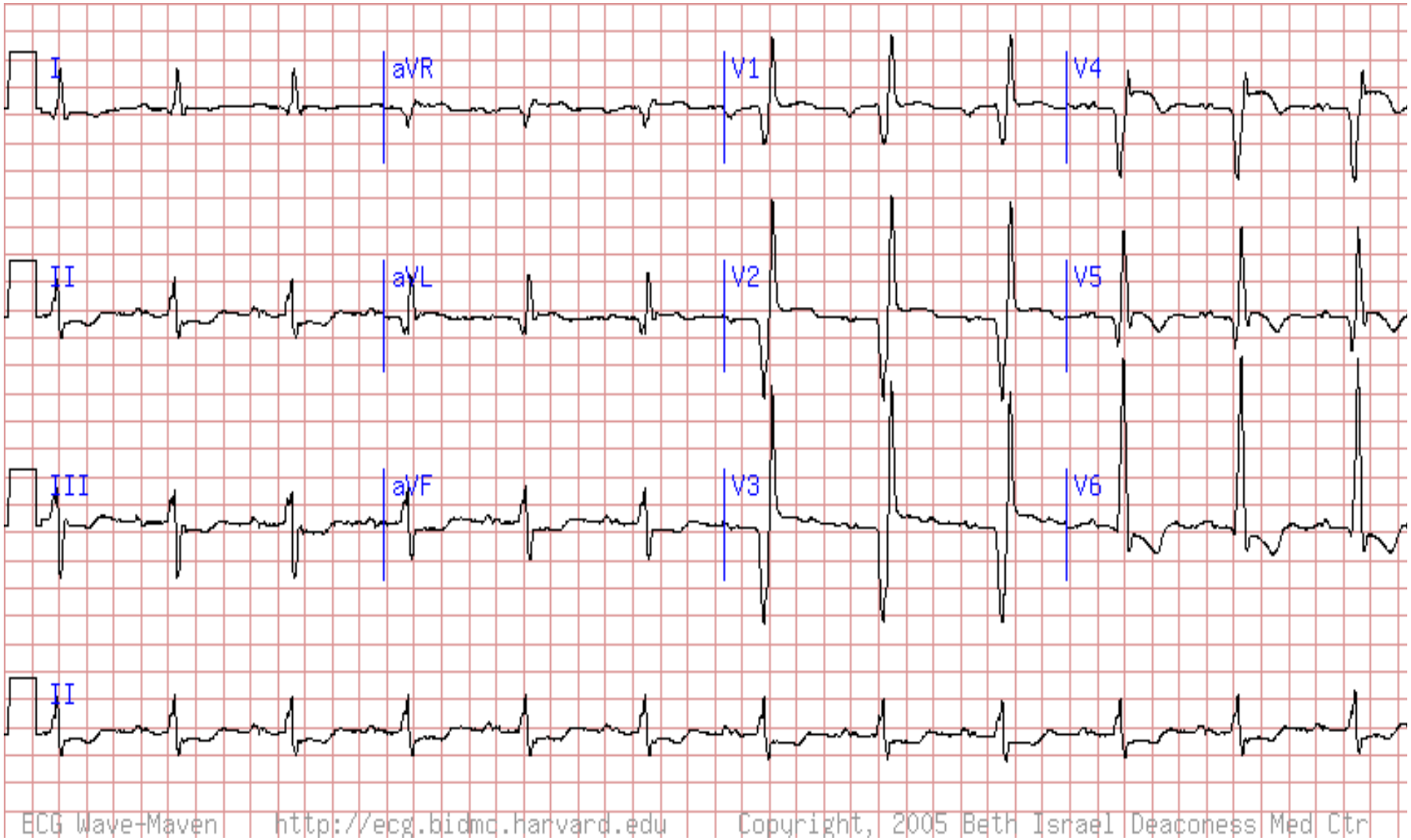
#May see PR segment depression, a manifestation of atrial injury


V1
V4
V2
V5
V3
V6
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Pericarditis



Ventricle aneurysm



ST depression

- >2mm usually indicates ischemia
- Common in normal ECG, especially in pregnancy
- But:
  - Non specific not more than 2mm below baseline
  - It is convex downward or slopes upwards from the S wave

Differential Diagnosis of ST Segment Depression

1-Normal variants or artifacts: Pseudo-ST-depression (wandering baseline due to poor skin-electrode contact)

2-Physiologic J-junctional depression with sinus tachycardia (most likely due to atrial repolarization)

3-Hyperventilation-induced ST segment depression

Differential Diagnosis of ST Segment Depression

4-Ischemic heart disease

Subendocardial ischemia (exercise induced or during angina attack)

ST segment depression is often characterized as "horizontal", "upsloping", or "downsloping"

5-Non Q-wave MI

6- Reciprocal changes in acute Q-wave MI (e.g., ST depression in leads I & aVL with acute inferior MI)

Differential Diagnosis of ST Segment Depression

7-Nonischemic causes of ST depression

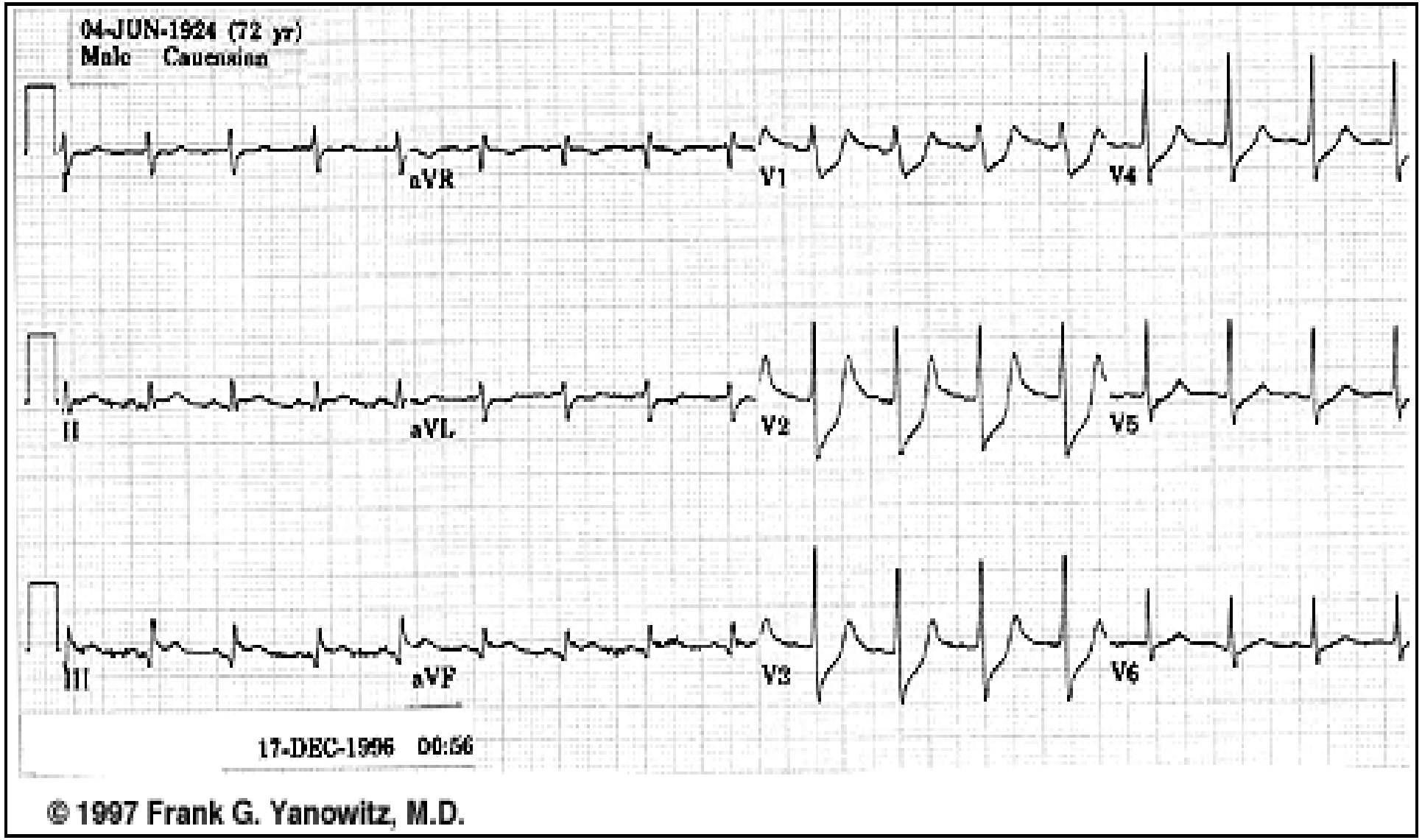
#RVH (right precordial leads) or LVH (left precordial leads, I, aVL)

Digoxin effect on ECG

Hypokalemia

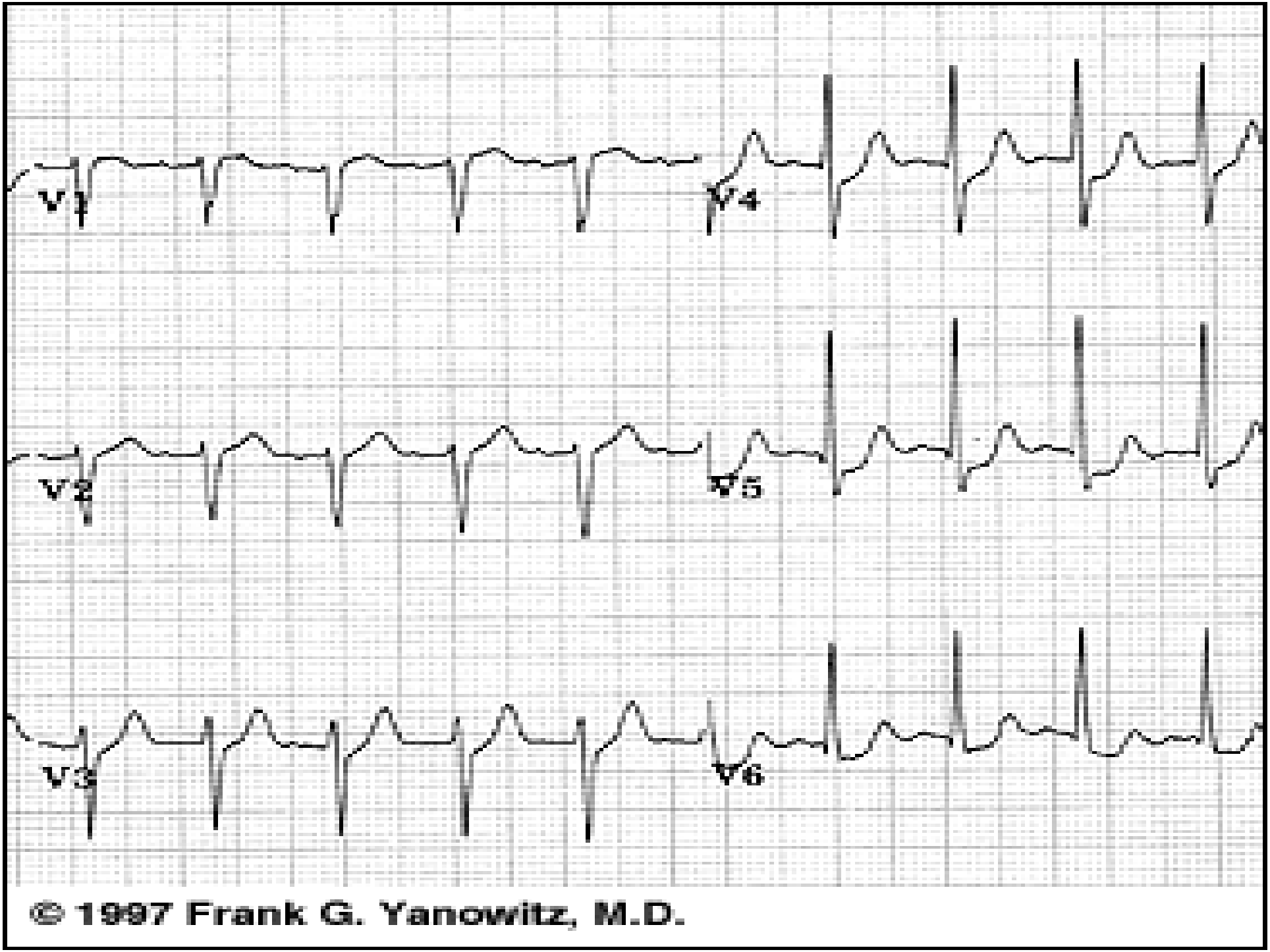
#Mitral valve prolapse (some cases)

#Secondary ST segment changes with IV conduction abnormalities (e.g., RBBB, LBBB, WPW, etc)



Acute inferoposterior MI

(note tall R waves V1-3, marked ST depression V1-3, ST elevation in II, III, aVF)

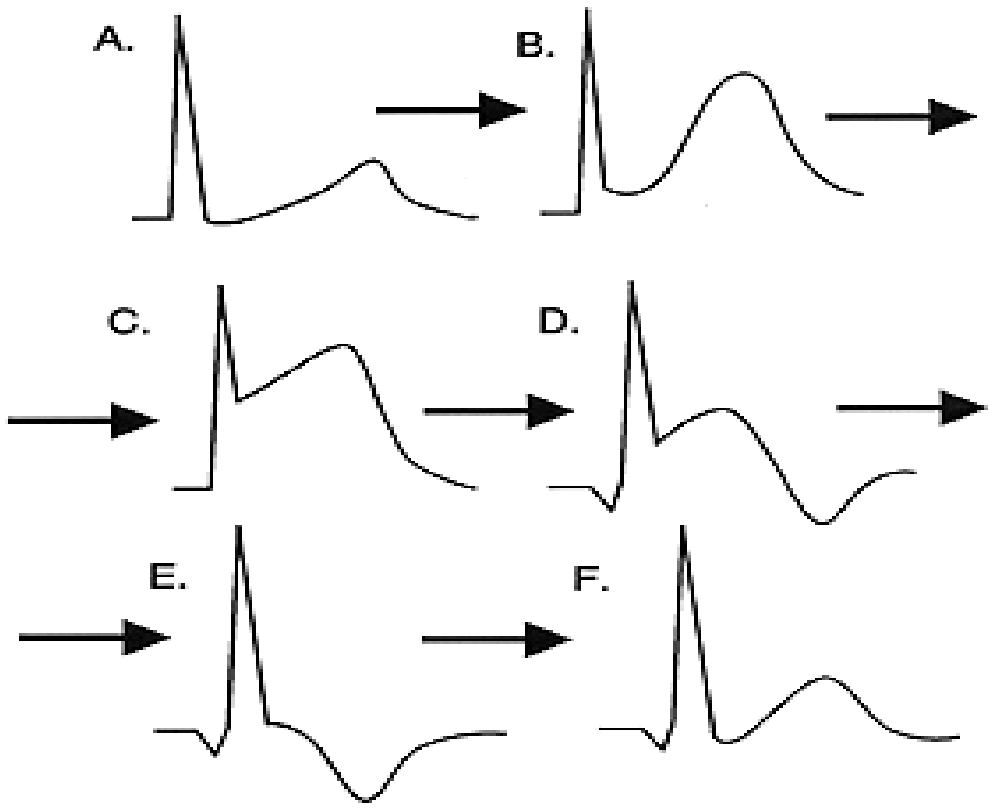

V1
V4
V2
V5
V3
V6
© 1997 Frank G. Yanowitz, M.D.

The ECG signs of Infarct!

- Abnormal Q waves
- ST segment elevation (Greater than 1mm in 2 or more adjacent leads)
- Inverted T waves

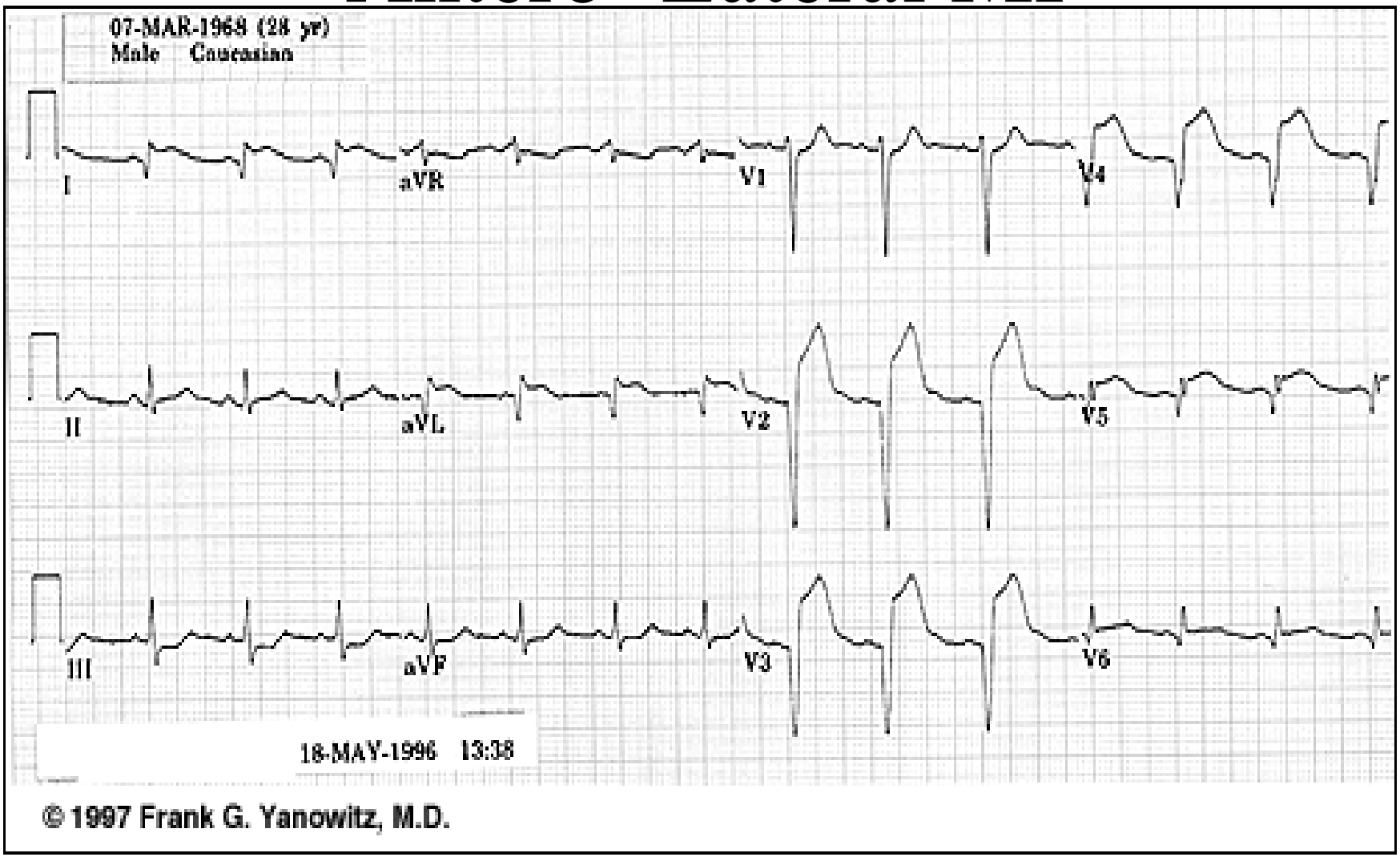
ST Elevation - Myocardial Infarction

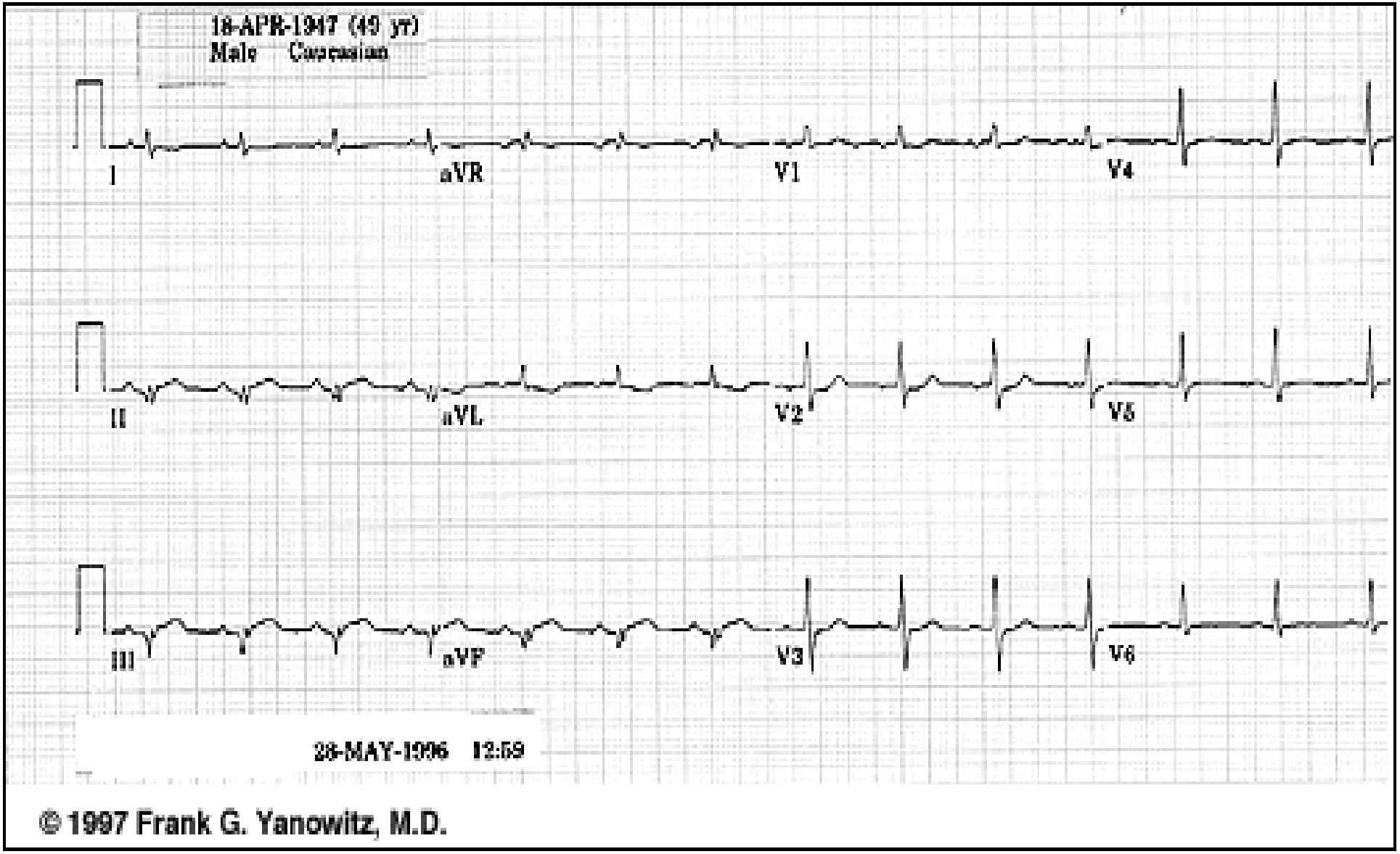
- ST elevation in two or more leads
  - Must be at least 1mm in limb leads
  - Must be at least 2mm in chest leads



Evolution of Acute MI

Antero -Lateral MI





Old inferoposterior MI (note tall R in V1-3, upright T waves and inferior Q waves)

T wave

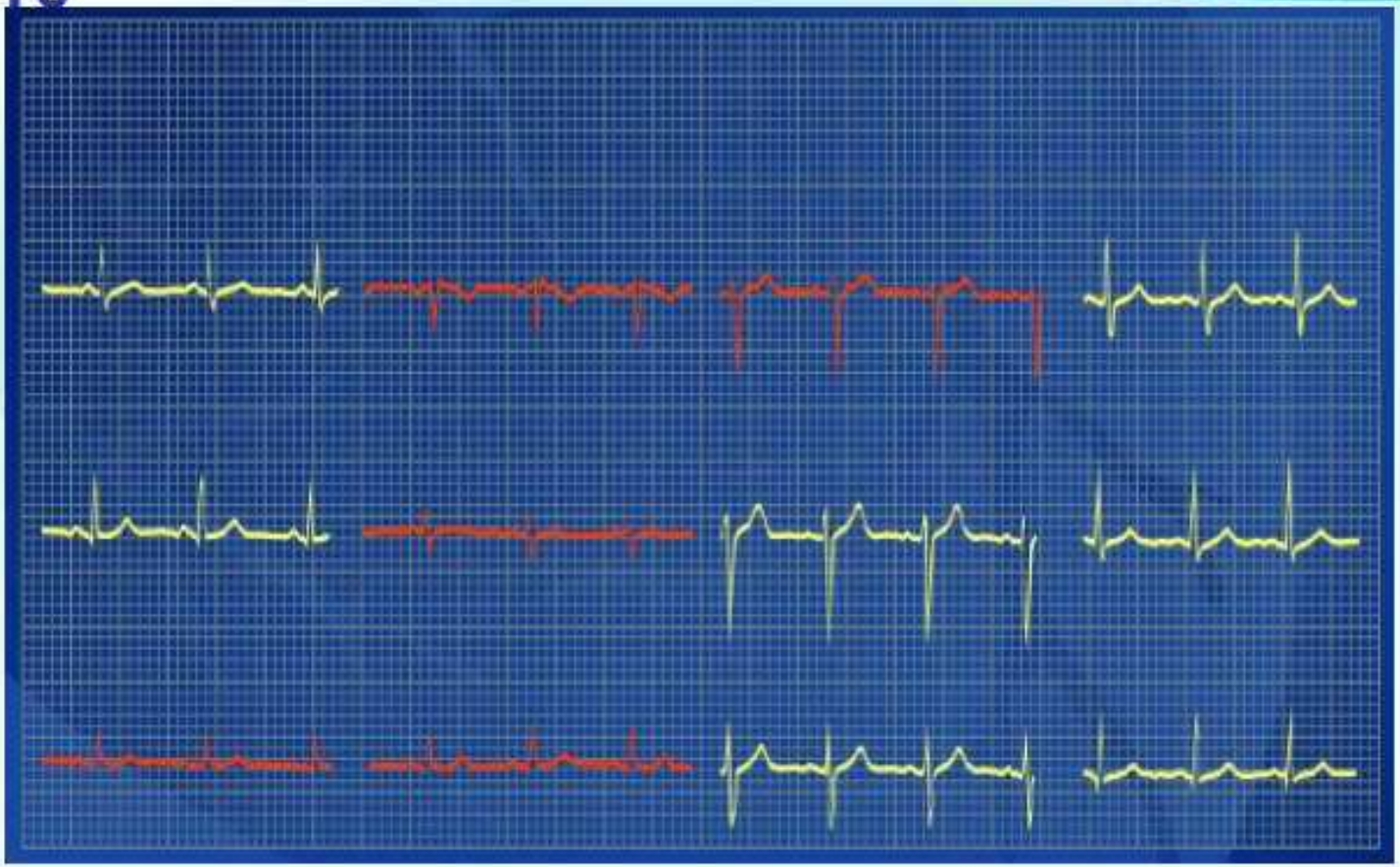
T wave

- T waves are normally upright in most leads but are always negative in aVR and often negative in leads III and V_1
- The T wave axis should be similar to the QRS axis
- T waves should be symmetrical
- Abnormal T waves can be caused by ischemia or infarction, hypertrophy, abnormal conduction patterns, drugs, metabolic changes, CNS events, etc.

NHS

Essex Cardiac Network

Rule 10



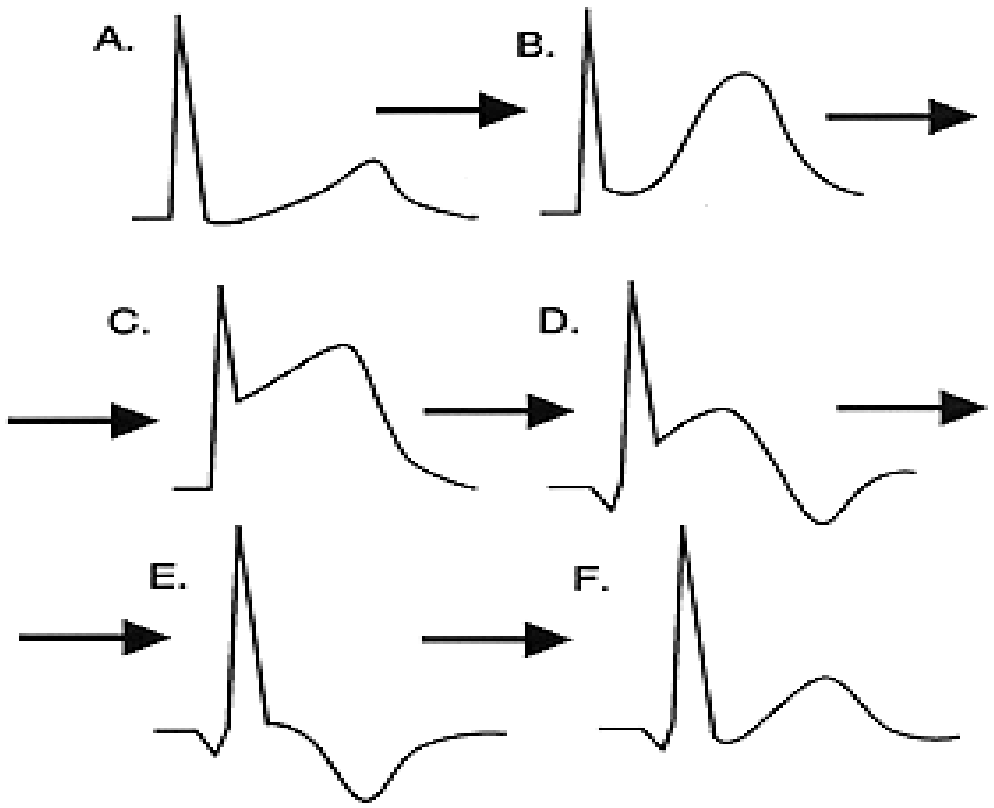
The T wave must be upright in I, II, V2 to V6

T wave: tall T waves(more than 2 big squares)

- Hyperkalaemia
- Hyperacute myocardial infarction
- Left bundle branch block (LBBB)

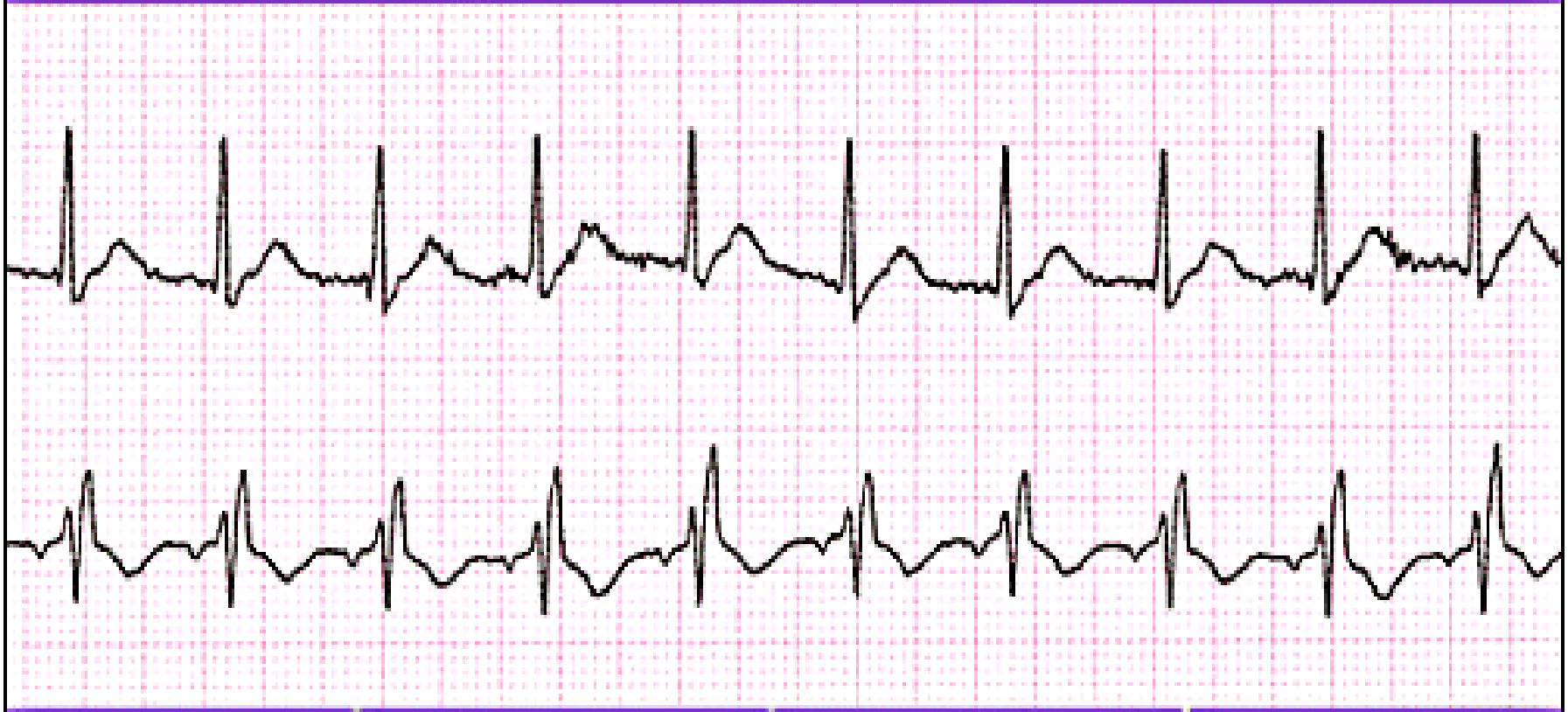
T waves: small, flattened or inverted

- Ischemia
- age, race
- hyperventilation, anxiety, drinking iced water
- LVH
- drugs (e.g. digoxin)
- pericarditis, PE
- intraventricular conduction delay (e.g. RBBB)
- electrolyte disturbance



Evolution of Acute MI

Right Bundle Branch Block

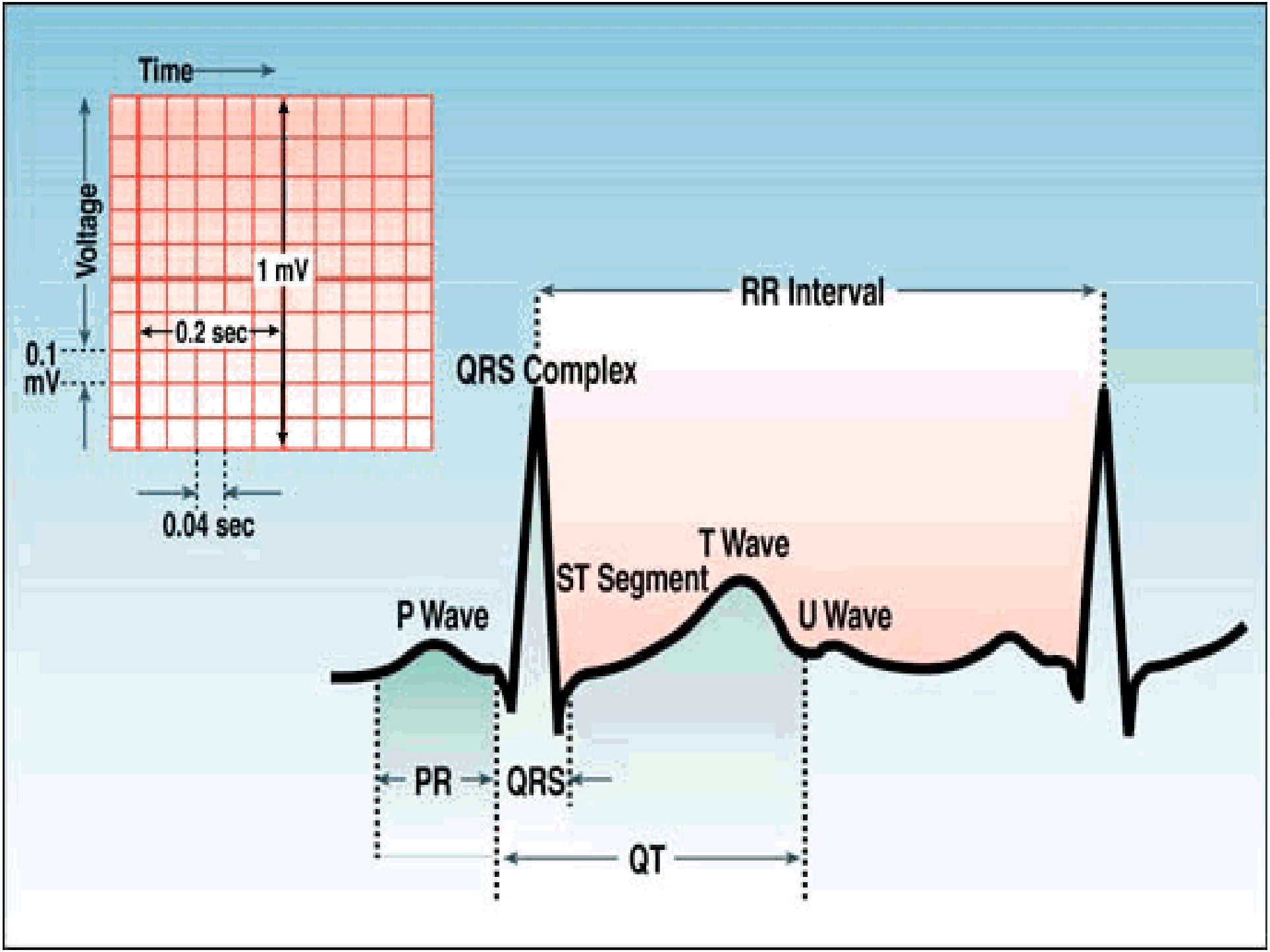


P Wave	PR Interval (in seconds)	QRS (in seconds)	Characteristics
Before each QRS, identical	.12 to .20	>.12	RSR' in V1

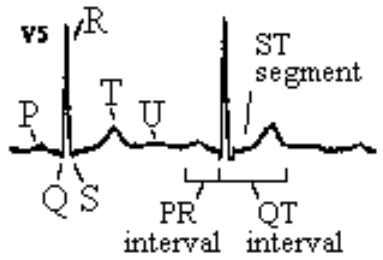
Abnormal T waves

- Inverted or flat where they should be upright
- Often asymmetric
- Often associated with abnormal ST segments (ST/T changes)

QT Interval


Time
Voltage
1 mV
0.2 sec
0.1 mV
0.04 sec
RR Interval
QRS Complex
T Wave
ST Segment
P Wave
U Wave
PR
QRS
QT

QT interval

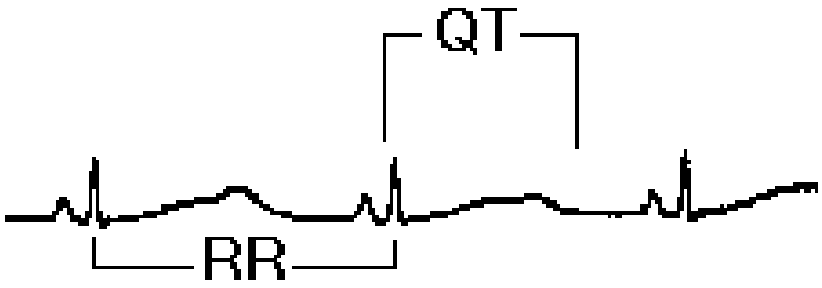


- measured from beginning of QRS to end of T wave
- QT Interval ($QT_c \leq 0.40$ sec) upper limit for QT_c = 0.44 sec

1-Bazett's Formula: QT_c = (QT)/SqRoot RR (in seconds)

2-***Poor Man's Guide*** to upper limits of QT: For HR = 70 bpm, QT≤0.40 sec; for every 10 bpm increase above 70 subtract 0.02 sec, and for every 10 bpm decrease below 70 add 0.02 sec. For example: QT ≤ 0.38 @ 80 bpm

QT ≤ 0.42 @ 60 bpm



$$QTc = \frac{QT}{\sqrt{RR}} = \frac{0.71}{\sqrt{1.11}} = 0.67 \text{ seconds}$$

QT interval

- Prolonged QT :
  A. Familial long QT Syndrome (LQTS)
  B. Congestive Heart Failure
  C. Myocardial Infarction
  D. Hypocalcemia & Hypokalaemia
  E. Hypomagnesemia
  F. Type I Antiarrhythmic drugs & Cispride
  G. Rheumatic Fever
  H. Myocarditis
  I. Congenital Heart Disease

- Short QT :
  A. Digoxin (Digitalis)
  B. Hypercalcemia
  C. Hyperkalemia

U wave

The U wave is the only remaining enigma of the ECG, and probably not for long. The origin of the U wave is still in question, although most authorities correlate the U wave with electrophysiologic events called "afterdepolarizations" in the ventricles.. The normal U wave has the same polarity as the T wave and is usually less than one-third the amplitude of the T wave. U waves are usually best seen in the right precordial leads especially V2 and V3. The normal U wave is asymmetric with the ascending limb moving more rapidly than the descending limb (just the opposite of the normal T wave).

Prominent upright U waves

1-Sinus bradycardia accentuates the U wave

2-Hypokalemia (remember the triad of ST segment depression, low amplitude T waves, and prominent U waves)

3- Quinidine and other type 1A antiarrhythmics

Negative or "inverted" U waves

1- Ischemic heart disease (often indicating left main or LAD disease) Myocardial infarction (in leads with pathologic Q waves)

2-During episode of acute ischemia (angina or exercise-induced ischemia)

3- During coronary artery spasm (Prinzmetal's angina)

4- Nonischemic causes Some cases of LVH or RVH (usually in leads with prominent R waves)

Thanks



